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THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

PROCEEDINGS

FOR

1905

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THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 15.

PRESENTED FEBRUARY 28TH, 1905.

THE NEW CROTON AQUEDUCT.

BY EDWARD WEGMANN,* C. E., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
ROBERT RIDGWAY, MYRON H. LEWIS, GEORGE I. BISCHOF AND THE AUTHOR.

Before describing the New Croton Aqueduct—the greatest work of its kind—it may be of interest to consider briefly the different steps in the development of the water-supply of the City of New York.

The first entry in the city's records referring to a public water-supply is contained in the following resolution which was passed on July 11, 1658, viz.:

"The Burgomasters resolved to communicate with the General relative to having a public well made in the Heere Straat" (the gentlemen's street, the present Broadway).

No further reference to this matter appears in the records, but we know that a public well was sunk about this time in Broadway at Bowling Green, just north of the site of the old fort. This was the only public well until February 27, 1677, when the Burgomasters and Schepens ordered six more public wells to be sunk. Other public wells were sunk later on and are all mentioned in the city's records.

In 1774, when New York had a population of about 22 000, Christopher Colles made a proposition to the Common Council for constructing public water-works, which was accepted. The works

* Expert Engineer to the Aqueduct Commission of the City of New York.

constructed consisted of a reservoir on the east side of Broadway between Pearl and White Streets; of a large well near the "Collect" (a large fresh-water pond occupying the space where now stand the Tombs and the surrounding blocks); of a steam-engine for pumping the water from the well to the reservoir, and of a system of distributing pipes, consisting of hollow logs. The works were put into operation in 1776, but were soon abandoned, owing to the confusion caused by the Revolution.

After the restoration of peace, the question of obtaining an ample water supply for New York was agitated from time to time, but no practical measures were taken in this direction until April, 1799, when the Manhattan Company was incorporated with a capital stock of $2 000 000, to supply the City of New York "with pure and wholesome water."

The charter of the company was obtained by Aaron Burr. What he really wished to have was the charter for a bank, but as that was almost impossible to obtain from the Legislature, owing to the prejudice that existed, at that time, against banks and similar institutions, Burr asked for a charter for a water company. He managed, however, to get the following clause in the proposed charter, which excited little attention at the time:

"And be it further enacted that it shall and may be lawful for the said company to employ all such surplus capital as may belong or accrue to the said company in the purchase of public or other stock, or in any other moneyed transactions or operations not inconsistent with the constitution and laws of this State or of the United States, for the benefit of said company."

Availing itself of the powers this clause conveyed, the Manhattan Company formed a powerful bank and did only enough towards supplying New York with water to maintain its charter.

A well, 25 ft. in diameter, was sunk on the north side of Reade Street, near the present Centre Street, in a thickly populated part of the city, from which water was pumped by a steam engine to a reservoir constructed on the north side of Chambers Street, near Centre Street. The water was distributed through hollow logs. The supply was neither ample nor pure.

A great many plans for obtaining a better water-supply for New York were proposed from time to time, but were opposed by the powerful influence of the Manhattan Company.

The necessity of having a larger supply was especially felt in cases of fire. In 1829 the Common Council had a small reservoir constructed on the south side of Thirteenth Street, on the line of Irving Place, solely for storing water for extinguishing fires.

The reservoir consisted of an iron tank, 44 ft. in diameter and 20½ ft. high, containing 233 169 gal., which was placed in an octagonal building. It was filled with water by steam engines which pumped from a well 16 ft. in diameter and 112 ft. deep. The water was distributed through two lines of cast-iron pipes 12 in. in diameter: one laid in Broadway and the other in the Bowery. This reservoir and its distributing pipes may be considered the beginning of the public water-works of the City of New York.

In response to repeated petitions from the Common Council of the City of New York, the State Legislature passed on February 25, 1833, an Act authorizing the Governor to appoint, with the consent of the Senate, five Commissioners, who were to make a thorough investigation of the best means of obtaining an ample supply of pure water for the City of New York.

The Commissioners were appointed at once and reported to the Common Council of the City and to the Legislature, after a year's investigation that, in their opinion, the Croton River was the only source from which the City could obtain a sufficient water-supply at a reasonable cost.

As the result of these reports the Legislature passed on May 2, 1834, "An Act to provide for supplying the City of New York with pure and wholesome water. This Act provided that the Governor should appoint, with the consent of the Senate, five Water Commissioners, who should prepare plans for a water supply for the City of New York, which were to be submitted to the Common Council. If this body approved of the plans, the question as to whether they were to be carried out or not was to be submitted to a vote of the citizens.

Under the above-mentioned Act the Governor appointed the same gentlemen Commissioners, who had made the preliminary investigations under the Act of the previous year. With the assistance of their Chief Engineer, Major D. B. Douglas, the Water Commissioners (as they were called) perfected plans for a supply from the Croton River, which were approved by the Common Council and

by a vote of the citizens, taken on April 14th, 15th and 16th, 1835. The works were constructed in 1837-1843 under the direction of J. B. Jervis as Chief Engineer. The new supply flowed to the City of New York on July 4, 1842, for the first time and the introduction of a copious supply of pure and wholesome water was celebrated on October 14, 1842, by a grand military and civic procession and by other appropriate festivities.

The works constructed, known now as the Old Croton Aqueduct and Reservoirs, in contradistinction to the New Croton works, built since 1884, included: 1st, a dam 50 ft. high across the Croton Valley, which formed a "fountain reservoir" known as Croton Lake; 2d, a masonry aqueduct about 38 miles long from Croton Lake to a receiving reservoir on Manhattan Island; 3d, a receiving reservoir 1 826 ft. long by 836 ft. wide, located on ground forming now part of Central Park; 4th, a pipe-line consisting of two lines of 36-in. mains; and, 5th, of a distributing reservoir of 24 000 000 gal. capacity built on Murray Hill, between the present Fortieth and Forty-second Streets, just west of Fifth Avenue.

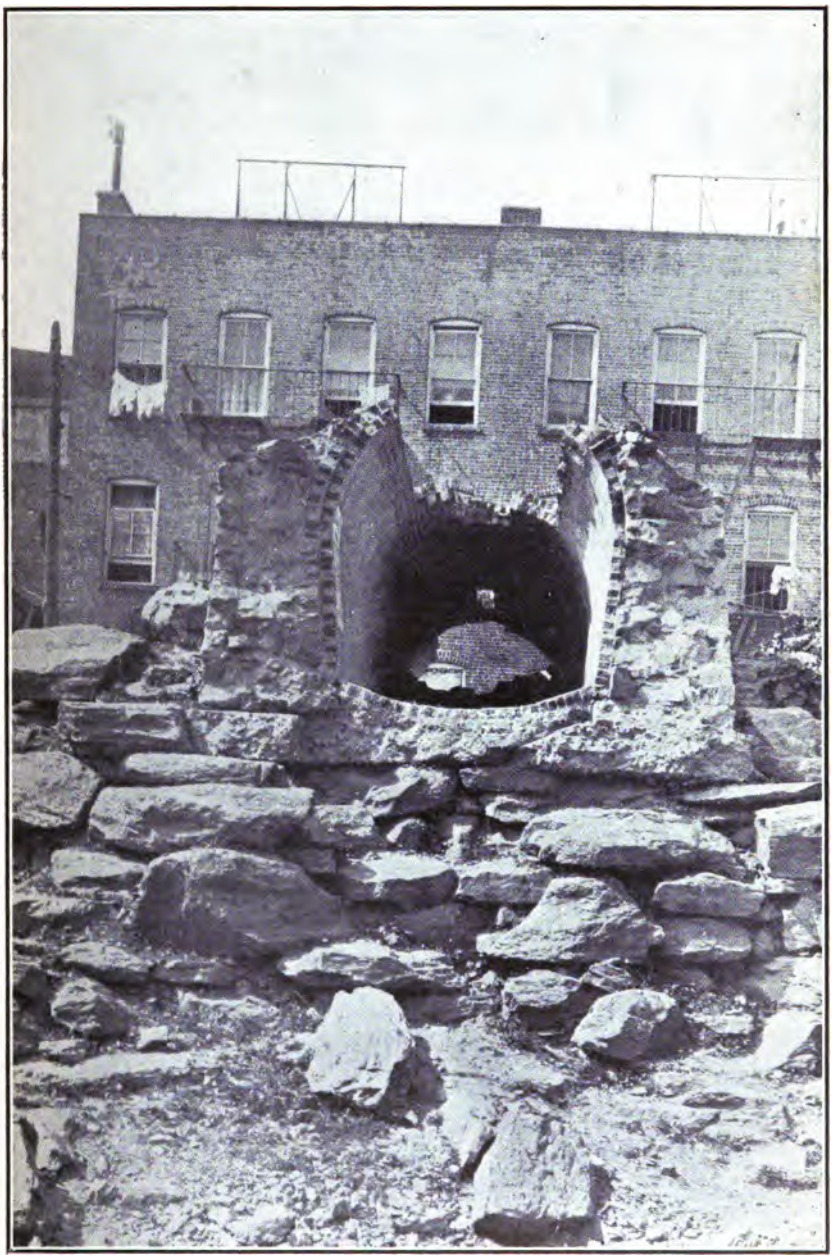
The total length of the Aqueduct from Croton Lake to the Distributing Reservoir was 40.56 miles. The total cost of the Old Croton Works was about $9 000 000.

Plate I shows the construction of the Old Croton Aqueduct. It is generally 8 ft. 5½ in. high by 7 ft. 5 in. wide. The area of the water channel when the Aqueduct is full contains 53.34 sq. ft.

The Aqueduct is carried across the Harlem River by a fine bridge (Plate II) 1 450 ft. long, known as "High Bridge." It is formed by piers and fifteen circular arches, eight of 80 ft. span and seven of 50 ft. span. The distance from the intrados at the soffit to high-water is 100 ft. Originally the Croton water was conveyed across this bridge in two lines of 36-in. mains.

In 1860-1864 a 90½ in. wrought-iron pipe was placed on top of the bridge, in addition to the two lines of 36-in. mains; the side walls were raised and a brick arch was built between them so as to form a vault for the pipes.

When the supply from the Croton River was introduced into New York in 1842, the city had a population of about 350 000 and the consumption of water was about 12 000 000 gallons per day.



OLD CROTON AQUEDUCT.

PLATE II.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

HIGH BRIDGE.

By 1880 the population had increased to 1 206 299 and the consumption of water averaged about 95 000 000 gal. per day.

According to the original plans the water level in the Aqueduct was never to be above the springing-line of the arch of the conduit, the maximum discharge for this level being estimated as about 72 000 000 gal. per day. To supply the increasing demand for water, the water-level in the Aqueduct had to be raised until it reached the crown of the arch. This caused pressures for which the old conduit had never been designed and necessitated the reinforcement of the arch of the Aqueduct.

By 1875 it was evident that a second aqueduct would soon be needed to bring sufficient water into the city to satisfy the increasing demand. Surveys for a new Aqueduct from the Croton Valley, having a capacity of 150 000 000 gal. per day, were made in 1875 under Gen. Fitz-John Porter as Commissioner of Public Works. This work could not, however, be undertaken at this time, owing to the deplorable condition of the City's finances, resulting from the maladministration of the Tweed ring.

As a small additional a supply of about 15 000 000 gal. per day was obtained from the Bronx River in 1880-1885.

The necessity of obtaining a much greater water supply continued, however, to make itself felt and the danger of depending on a single Aqueduct, which was being severely strained to meet the demand for water, was also apparent.

The City's finances having recovered from the disorder caused by the Tweed ring, the Legislature passed on June 1, 1883: "An Act to provide new reservoirs, dams and a new aqueduct, with the appurtenances thereto, for the purpose of supplying the City of New York with an increased supply of pure and wholesome water," known as Chapter 490 of the Laws of 1883.

According to this Act, the work of building the new waterworks was to be entrusted to an Aqueduct Commission consisting of the Mayor, Comptroller and Commissioner of Public Works of the City of New York, *ex officiis,* and of three citizens, named in the Act. The composition of the Aqueduct Commission was modified by Chapter 337 of the Laws of 1886, and by Chapter 584 of the Laws of 1888. At present, the Commission consists of the Mayor

and Comptroller, *ex officiis,* and of four citizens who were appointed by the Mayor.

The first work undertaken by the Aqueduct Commissioners was the construction of a new aqueduct to the Croton Valley, which was built in 1885 to 1893. The work was sufficiently completed by July 15, 1890, to allow the water to flow through the new conduit from Croton Lake to the Central Park Reservoir. Later on the Commissioners constructed additional storage reservoirs in the Croton water-shed, and they have still under construction a large receiving and distributing reservoir at Jerome Park in the 24th Ward of the City.

The writer will endeavor to give in this paper a general description of the construction of "the New Croton Aqueduct."

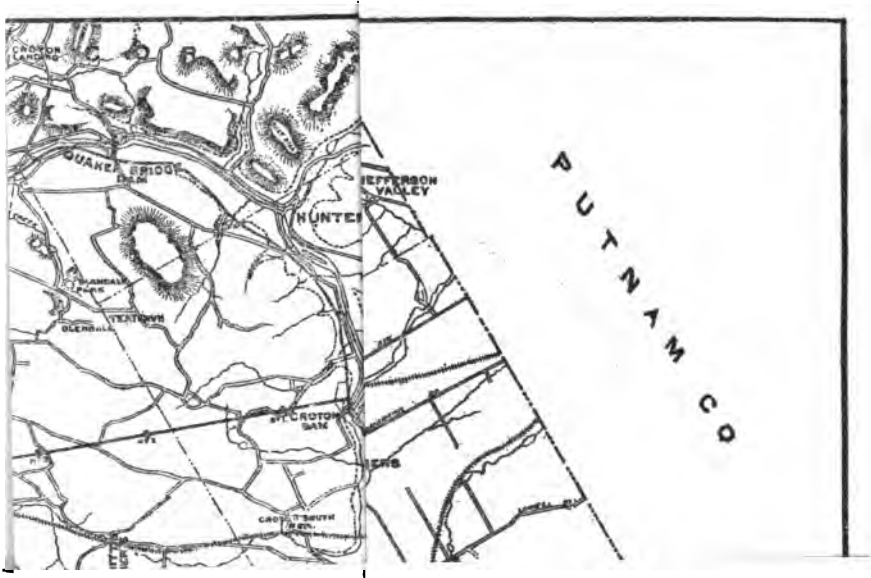
According to the Aqueduct law (Chapter 490 of the Laws of 1883) the original plans for the New Aqueduct and reservoirs were to be prepared by the Department of Public Works and to be submitted to the Aqueduct Commissioners, who had the right to adopt or to modify them as they might deem best.

The plans prepared by the Department of Public Works contemplated the construction of a high masonry dam across the Croton Valley at "the Quaker Bridge," about 5 miles above the mouth of the river, and the construction of a circular aqueduct having an inner diameter of 12 ft. from a point near the proposed dam to the large receiving reservoir in Central Park. Owing to the great improvements made in rock-boring tools and in explosives, it was proposed to build the new Aqueduct almost entirely in tunnel in as direct a line as possible.

At the "public hearings" held by the Aqueduct Commissioners much opposition arose to the proposed high masonry dam. This caused considerable delay in the construction of this dam. It was finally located about 1¼ miles up-stream from the Quaker Bridge, and its construction was begun in 1892. The New Croton Dam, as this structure is named, will be completed this year (1905), and the large reservoir it will form, having a storage capacity of about 30 000 000 000 gal., will be put at once into service.

If the inlet into the new aqueduct had been located near the high dam, the aqueduct could not have been used until the dam and reservoir had been completed. To avoid this delay the Aqueduct

PLATE III.
THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.
WEGMANN ON THE NEW CROTON AQUEDUCT.



Commissioners wisely decided to construct the inlet gate-house of the new aqueduct near the Old Croton Dam and to connect it with Croton Lake by a by-pass. This made it possible to put the new conduit in service in 1890 without waiting for the construction of the high dam, which had not even been begun at that time.

Another advantage of the site selected for the inlet into the new aqueduct was that this conduit could be located some miles back from the Hudson River through property that was not nearly as valuable as that along the river front, where the Department of Public Works had originally located the Aqueduct. Plate III shows the location and profile of the New Croton Aqueduct.

As already stated the conduit was to be circular, with an inner diameter of 12 ft., according to the original plans, which gave it with the proposed grade a capacity of about 250 000 000 gal. a day. The Aqueduct Commissioners decided to increase the inner diameter of the Aqueduct to 14 ft. from the inlet to Jerome Park in the 24th Ward of the City, where it was proposed to construct a large receiving and distributing reservoir. With an inner diameter of 14 ft. the discharge of the Aqueduct on the established grade of 0.7 ft. per mile was calculated to be about 300 000 000 gal. per day. It was decided to discharge 50 000 000 gal. of this quantity into the proposed reservoir and to convey the remainder to Manhattan Island. To carry out this plan the diameter of the conduit was reduced at Jerome Park to 12 ft. 3 in.

If the same grade of 0.7 ft. per mile had been continued south of Jerome Park, the Aqueduct would have been located at or near the surface through valuable city property. To avoid the expense for right of way which this would have entailed, the grade line was depressed at Mosholu Avenue, just north of the proposed Jerome Park reservoir, 115.64 ft. by an incline on a 10% grade. The grade was then continued 0.7 ft. per mile to within 1 100 ft. of the Harlem River, where it was lowered 127.5 ft. by a second incline having a 15% grade. This brought the Aqueduct to the level at which it had been decided to tunnel under the Harlem River, viz., about 150 ft. below high water. As will be explained hereafter the attempt to cross under the river at this level was abandoned on account of the bad rock that was en-

countered. The grade of the Aqueduct was lowered 172 ft. more by a short tunnel and a vertical shaft and the tunnel was driven about 307 ft. below high water through solid rock (lime-stone and gneiss).

The inner diameter of the Aqueduct under the Harlem River was made only 10½ ft., partly to reduce the size of the tunnel through ground which might prove to be dangerous and partly to increase the velocity of the current in the siphon under the river to avoid any deposit of silt.

At the Manhattan side of the Harlem River, the aqueduct is connected with a large shaft, known as Shaft No. 25, which has two circular wells, each 12 ft. 3 in. in diameter. One of these wells forms the continuation of the aqueduct to a level about 13.5 ft. above high water, where the aqueduct tunnel constructed on Manhattan Island joins this shaft. The other well is known as the pump-well and serves for pumping out the siphon under the Harlem River, whenever this may be necessary for inspection or repairs, as described hereafter.

From Shaft No. 25 the aqueduct is constructed in tunnel with a rising grade to the south of .065 ft. in 100 ft. to a terminal gate-house constructed at One Hundred and Thirty-fifth Street and Convent Avenue. At a point near this gate-house the Aqueduct rises 26.30 ft. on a 15% grade and then vertically to the main water-chamber of the gate-house.

From the One Hundred and Thirty-fifth Street gate-house the water is conveyed by eight lines of 48-in. mains, laid in Convent Avenue (Plate IV) to One Hundred and Twenty-fifth Street. Four of these lines of pipe are connected direct with the distributing system and the other four are continued to the large Central Park receiving reservoir, into which they discharge through a small gate-house.

At the lowest point of the pipe-lines, viz., at One Hundred and Twenty-fifth Street, each of the pipe-lines is provided with a 12-in. blow-off, which discharges into the sewer in Manhattan Street.

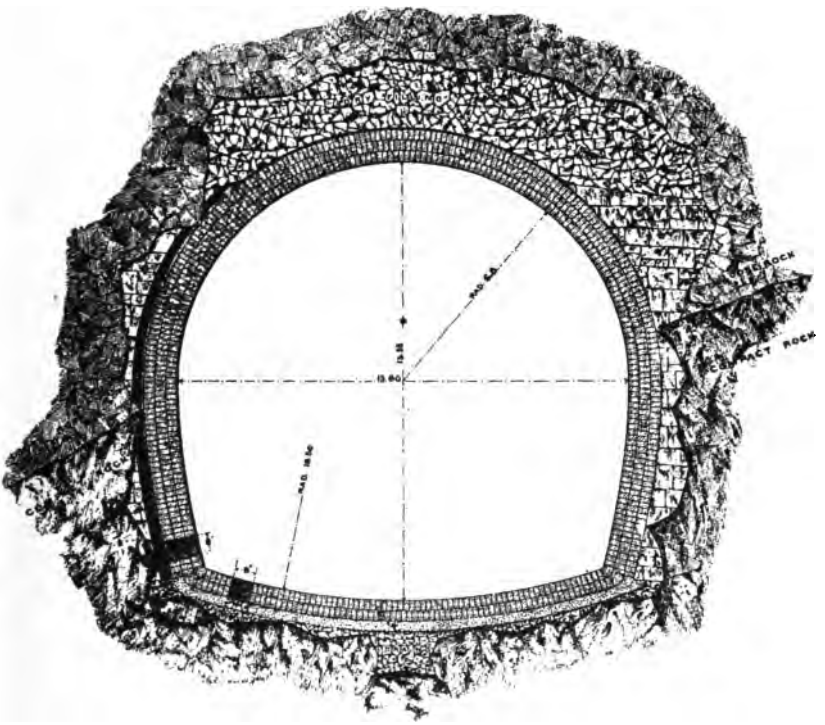
It will be seen from the above description that the New Croton Aqueduct consists of the following three parts:

FIG. 1.—PIPE-LINE ON CONVENT AVENUE.

FIG. 2.—PIPE-LINE IN CENTRAL PARK.

PLATE V.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

AQUEDUCT IN COMPACT AND LOOSE ROCK



1st. A masonry conduit "not under pressure," except in a short siphon constructed under Gould's Swamp, from the inlet to Mosholu Avenue, near the Jerome Park Reservoir.

2d. A masonry conduit "under pressure" from Mosholu Avenue to the One Hundred and Thirty-fifth Street gate-house.

3d. A pipe line from the above gate-house to the Central Park Reservoir.

The lengths of these different parts of the Aqueduct are as follows:

	MILES.
Masonry conduit not under pressure except in the siphon under Gould Swamp	23.92
Masonry conduit under pressure	6.83
Pipe-line	2.35
Total length	33.10

The Aqueduct under pressure and the pipe-line form an inverted siphon 9.18 miles long.

According to the plans of the Department of Public Works the new Aqueduct was to be circular. To facilitate, however, the construction of the Aqueduct tunnel, the Aqueduct Commissioners decided to build that part of the conduit which was not to be under pressure according to the horse-shoe section shown in Plate V. This shape had two advantages: It provided more room for the tracks which had to be used during construction, and it made it possible to leave these tracks undisturbed until the very last work, the side walls and arch of the conduit being constructed first and the invert last.

The "horse-shoe section" was designed to give exactly the same maximum discharge as that of a circular conduit having an inner diameter of 14 ft. When such a conduit is not subjected to pressure, the flow being that due to its grade, the maximum discharge will occur when the water level in the conduit subtends an arc of 52° at the crown of the arch, the verse-sine of this arc being 0.101 $\times$ the radius of the arc. If the water level rises above this point more is lost (at least theoretically) by the increased friction than is gained by the increased water-area.

Those portions of the Aqueduct which were to be subjected to pressure were made circular. The siphon under Gould's Swamp, which has a length of 1 135 ft., was given an inner diameter of 14 ft. 3 in. As already stated the conduit from Mosholu Avenue to the One Hundred and Thirty-fifth Street gate-house was given an inner diameter of 12 ft. 3 in., except under the Harlem River, where this diameter was reduced to 10½ ft.

The Aqueduct tunnel was lined for its whole length with masonry, viz., first with brickwork, 12-20 in. thick according to the strength required, and then with rubble masonry to the sides of the rock excavation. For the "Aqueduct not under pressure" this rubble was only brought up to the level of the haunches of the rock and a packing of dry masonry was put on top of the arch to the roof of the tunnel. For the "Aqueduct under pressure" rubble masonry laid in cement mortar was used between the brick lining and the top, bottom and sides of the tunnel excavation. Plate VI, Fig. 1, shows how the Aqueduct was constructed in open cut.

In wet ground "weepers" (small openings) were left in the sides and bottom of the masonry lining of the "Aqueduct not under pressure" at intervals of about 20 ft. to admit the ground water, which was of good quality. Gaugings showed that about 4 000 000 gal. per day entered the Aqueduct in this manner.

No "weepers" were constructed in the "Aqueduct under pressure" except in the tunnel under the Harlem River, where bronze flap-valves were placed to act as weepers, opening when the tunnel is empty and closing when it is full of water. These valves were placed at wet points, and small channels were left in the backing masonry to lead the water to the weeper-valves.

Owing to the great depth at which the Aqueduct was constructed under the Harlem River (about 307 ft.) this tunnel was almost dry.

After most of the Aqueduct had been lined with masonry, the engineers discovered that, in some cases, the rubble backing masonry, which was to be laid between the brickwork and the sides and roof of the tunnel excavation, had either been omitted or had been laid either dry or nearly dry, where cement mortar was to be used. Cavities, which in some cases were filled with empty cement barrels, were thus left in the backing masonry, especially on top

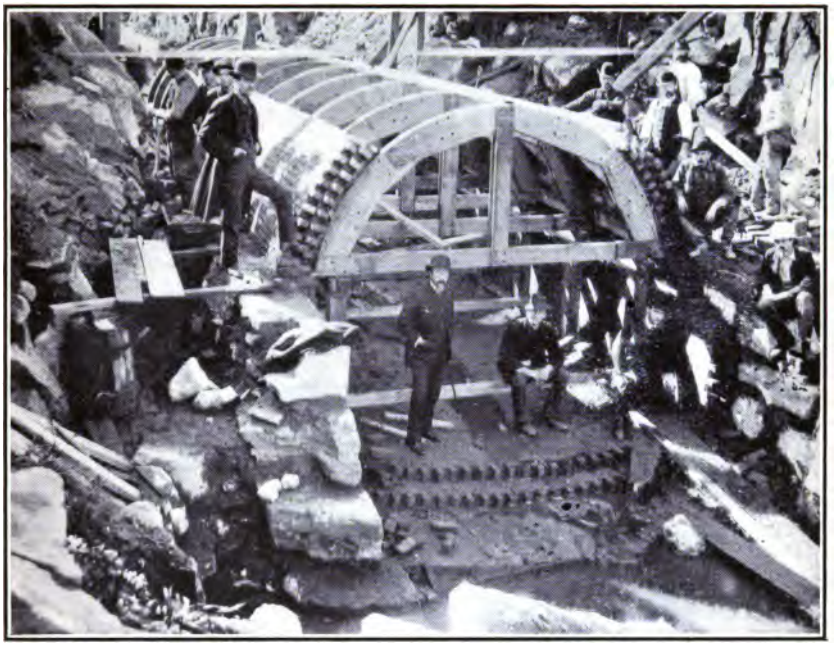


FIG. 1.—AQUEDUCT IN OPEN CUT.

FIG. 2.—CAVITY DISCOVERED ABOVE THE ARCH OF THE AQUEDUCT.

Thirty-fifth Street having been fixed as eight, the head required by these pipe-lines for discharging 250 000 000 gal. per day was next determined. In like manner the head required for the Aqueduct under the Harlem River, whose inner diameter had been fixed at 10½ ft., was calculated. The remaining head was available for the conduit under pressure from Mosholu Avenue to One Hundred and Thirty-fifth Street, not including the portion under the Harlem River. The inner diameter of this conduit was calculated to be 12 ft. 3 ins. for the required discharge of 250 000 000 gal. per day.

From the inlet gate-house at Croton Lake to the terminal gate-house at One Hundred and Thirty-fifth Street—a distance of $30\frac{75}{100}$ miles—the Aqueduct was constructed entirely below ground. At five points aggregating $1\frac{12}{100}$ miles in length the excavation was made in open trench, but for the remaining $29\frac{63}{100}$ miles it was made by tunneling.

In order to drive this tunnel 40 shafts were sunk and two inclines were excavated. The depth of the shafts from the surface to the top of the tunnel varied from 21 to 391 ft., the average depth being 127 ft.

From Croton Lake to the Harlem River the shafts were generally located 4 000-7 500 ft. apart, except at difficult points, such as at Gould's Swamp, at the crossing of the Sawmill River, etc., where the distance between shafts was reduced to 400-1 200 ft. On Manhattan Island, where the shafts were sunk in the middle of the avenues under which the Aqueduct was constructed, the shafts were about 1 400-2 700 ft. apart. The average distance between adjacent working points of the tunnel (shafts, inclines and portals at cuts) was 3 382 ft.

The standard cross-section of the shafts was 8 by 17½ ft. in the clear, the longer dimension being placed parallel with the center-line of the Aqueduct in order to give the engineers as long a base line as possible to produce from the bottom of the shafts. This base-line was obtained by suspending two 25-lb. weights from No. 8 piano steel wire, which had been annealed. The wires were placed exactly on the center-line of the tunnel and the weights were usually placed in buckets of water at the foot of the shaft, in order to steady the wires as much as possible. The small base-line given by the two wires, which were usually about 15 ft. apart, had to be

FIG. 1.—HEAD-HOUSE OF SHAFT NO. 25.

FIG. 2.—HEAD-HOUSE OF SHAFT NO. 29 IN AMSTERDAM AVENUE.

PLATE VIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

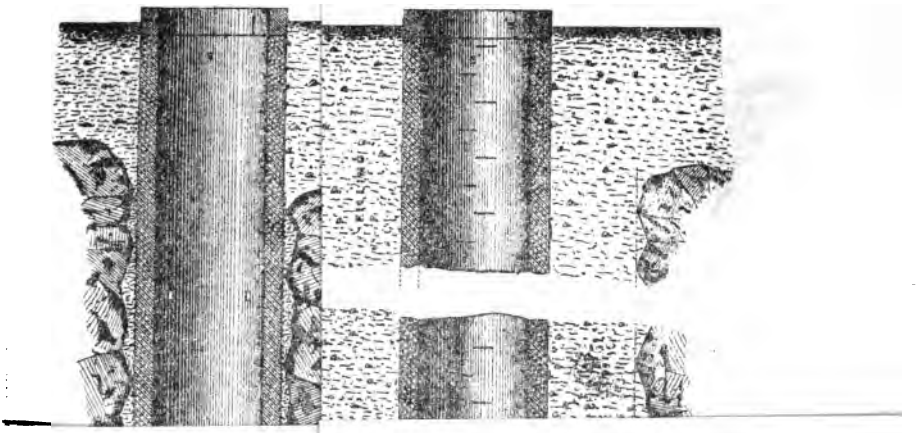


PLATE IX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

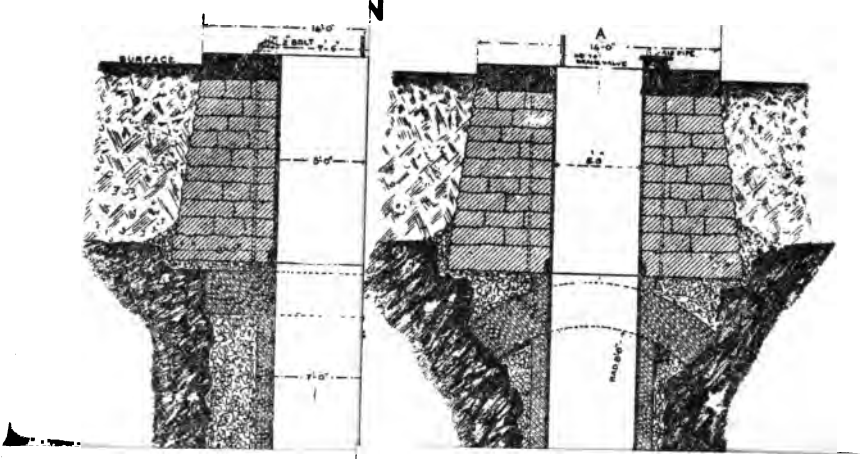


PLATE X.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

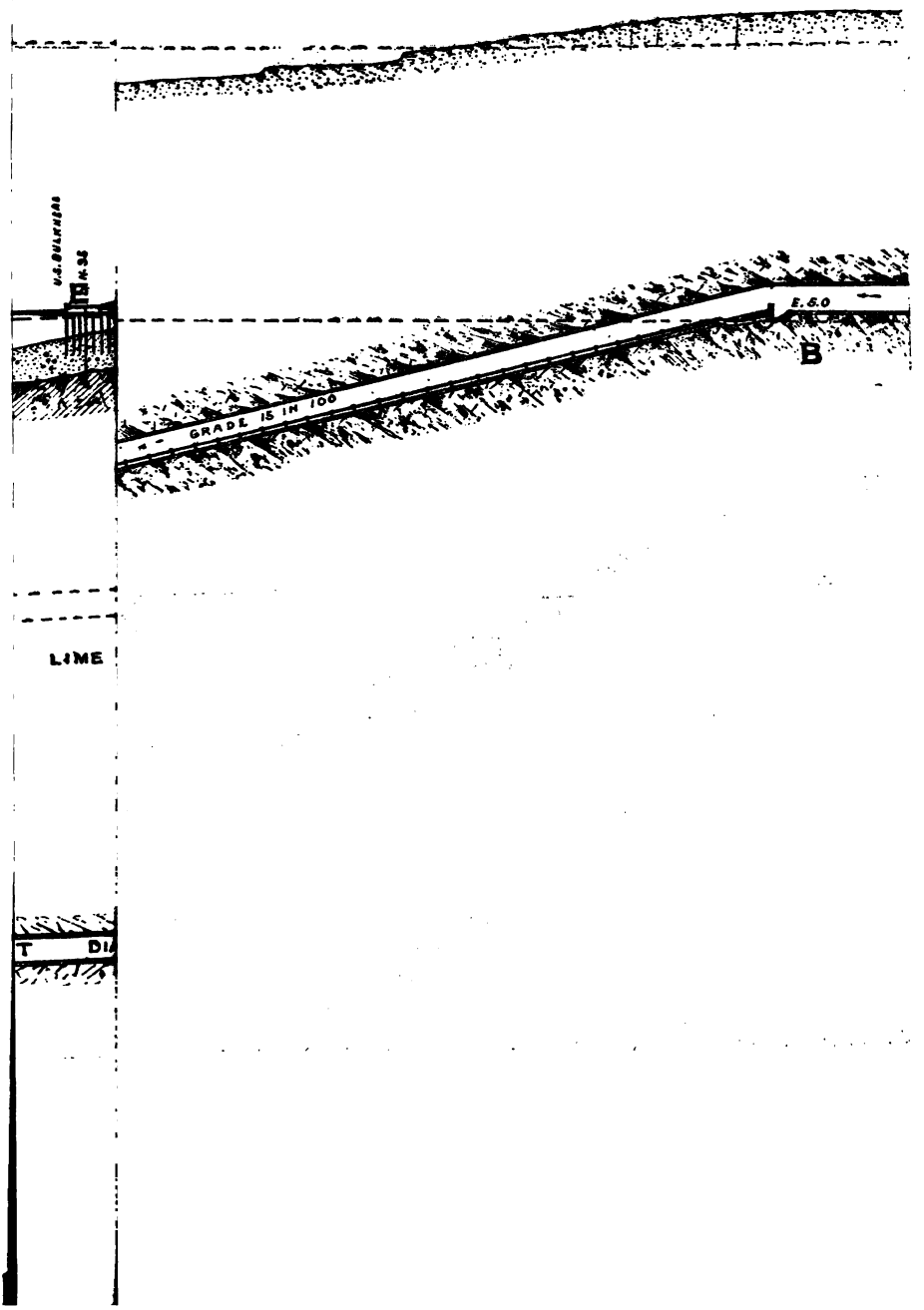
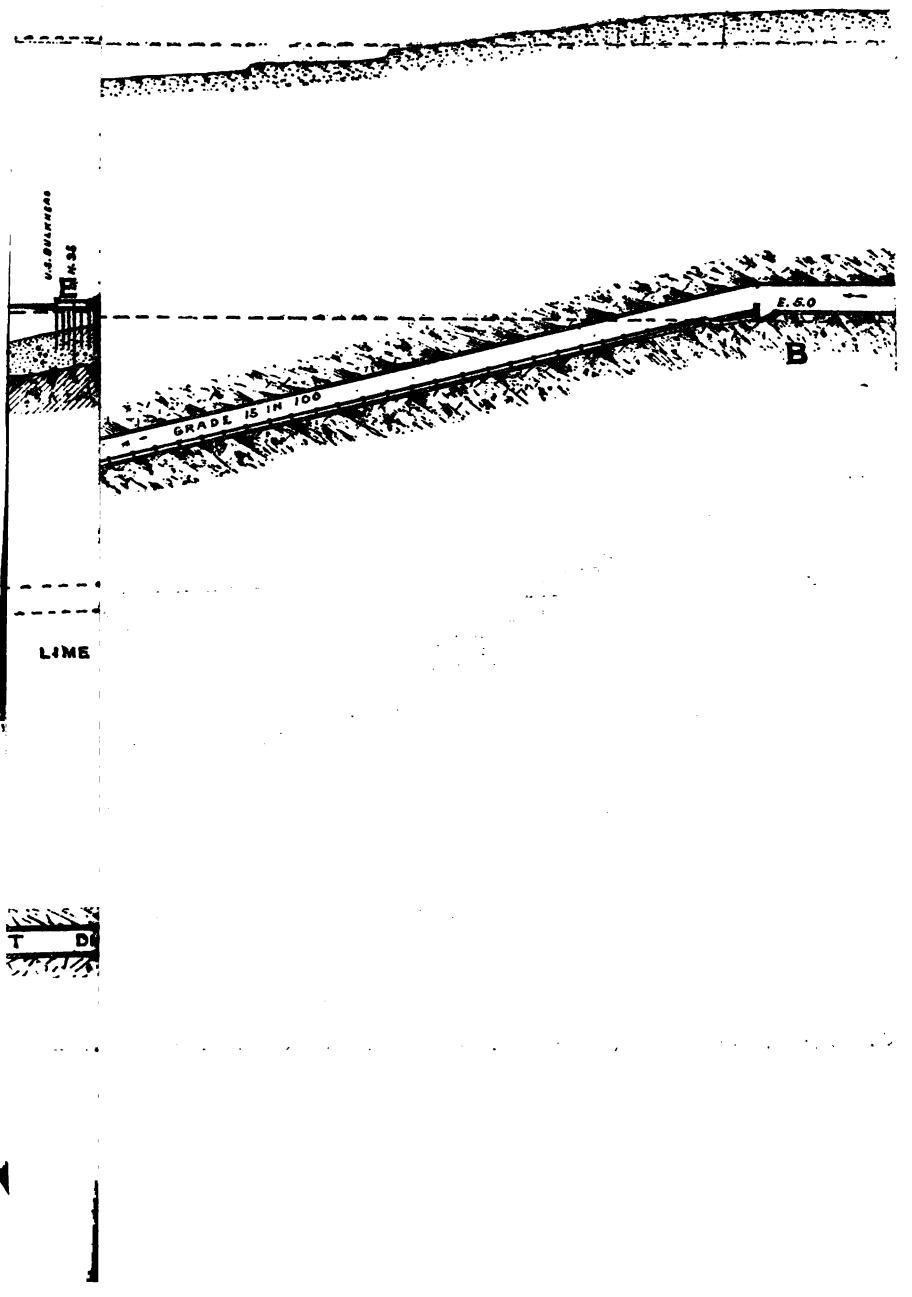


PLATE X.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.



produced into the headings. This was done with ordinary engineers' transits.

Shaft No. 25 (Plate VII, Fig. 1) on the Manhattan side of the Harlem River, which has already been mentioned, was excavated 16½ x 33 ft. in the clear to provide sufficient room for the two 12 ft. 3 in. wells. It was the deepest shaft, the distance from the surface to the bottom of the sump being 426.5 ft.

Plate VII, Fig. 2, shows the head-houses over shaft No. 29. Until the headings had advanced about 100 ft. from the shafts all the material excavated was removed in buckets. Elevators—two for each shaft—were then used instead of the buckets. All of the shafts for the "Aqueduct not under pressure" were lined with masonry (Plate VIII) and left open, so as to form ventilators and points where the Aqueduct might be entered. For the "conduit under pressure," some shafts were lined with masonry and closed by manhole plates (Plate IX), and the others were closed with masonry to a certain height and then filled in.

In driving the long Aqueduct various kinds of ground were encountered; solid rock, loose rock, earth, sand and liquid mud. Unusual difficulties were met with only at a few points.

The most difficult piece of work was involved in constructing the tunnel through the soft ground (mud) in the south heading of shaft No. 13, from which about 160 gal. of water per minute had to be pumped. This soft material (sand, gravel, clay and decomposed rock) had a depth of about 160 ft. from the surface of the ground to the Aqueduct tunnel and extended for 110 ft. along the center-line. About a year's time was consumed in constructing the Aqueduct through this bad ground. After several ineffectual attempts the excavation was finally made by the "English" or crown-bar system.

In the south heading of shaft No. 17 the excavation had to be made through running sand for 43 ft. A heavy timber bulkhead, which was constructed at the end of the heading when the sand was encountered, was crushed by the great pressure of the sand.

One of the most important pieces of work was the tunnel under the Harlem River (Plate X). The diamond-drill borings, made by the Department of Public Works, had indicated that there was a soft seam in the rock under the river, about 300 ft. from Manhattan

Island. The engineers of the Aqueduct Commission located the Aqueduct tunnel about 150 ft. below high-water. This was supposed to insure a roof about 30 ft. thick of solid rock.

The tunnel was driven entirely from Shaft No. 25 on the west (Manhattan) side of the river. When the heading had advanced about 300 ft. water commenced to pour into the tunnel through the drill-holes. A diamond drill was placed in the heading and additional test-holes were drilled both in a horizontal and inclined direction, as shown on Plate X. These test-holes proved that, instead of stopping 30 ft. above the tunnel, the pocket of soft material continued for at least 75 ft. below the tunnel. In front of the breast of the tunnel the rock was found to be entirely disintegrated for 26 ft. After this hard lime-stone was encountered, but it contained seams full of water under the full pressure due to the river.

The tunnel might have been successfully advanced through the decomposed rock (sand), but the large quantity of water that might have flowed into the tunnel from the seams in the lime-stone might have been an insurmountable obstacle.

After careful consideration the Aqueduct Commissioners decided to abandon the 300 ft. of tunnel that had been made from Shaft 25; to sink this shaft 150 ft. deeper, and to drive the tunnel at a depth of about 307 ft. below high-water. This was done successfully, hard gneiss and lime-stone being encountered at the depth at which the tunnel was driven.

In driving the Aqueduct tunnel on Manhattan Island, south of Shaft No. 30 a seam of soft, slippery material (talc, clay, and decomposed rock), about 12 in. wide, was discovered on the west side of the tunnel. Although ordered by the engineer to timber the tunnel the contractors failed to do so and continued the excavation as though the rock had been solid. The result of this carelessness was a bad "cave-in" which filled the tunnel with heavy blocks of rock and stopped the work at this point for a month.

The excavation through the loose rock was finally made by means of crown-bars. Small drifts were made for placing these bars above the space required for the masonry of the conduit. The crown-bars were afterward supported by heavy timber frames which were erected as the excavation of the loose material progressed.

At the place where the "cave-in" occurred the tunnel is about

IRON LINING FOR AQUEDUCT THROUGH LOOSE ROCK SOUTH OF SHAFT NO. 30.

PLATE XII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

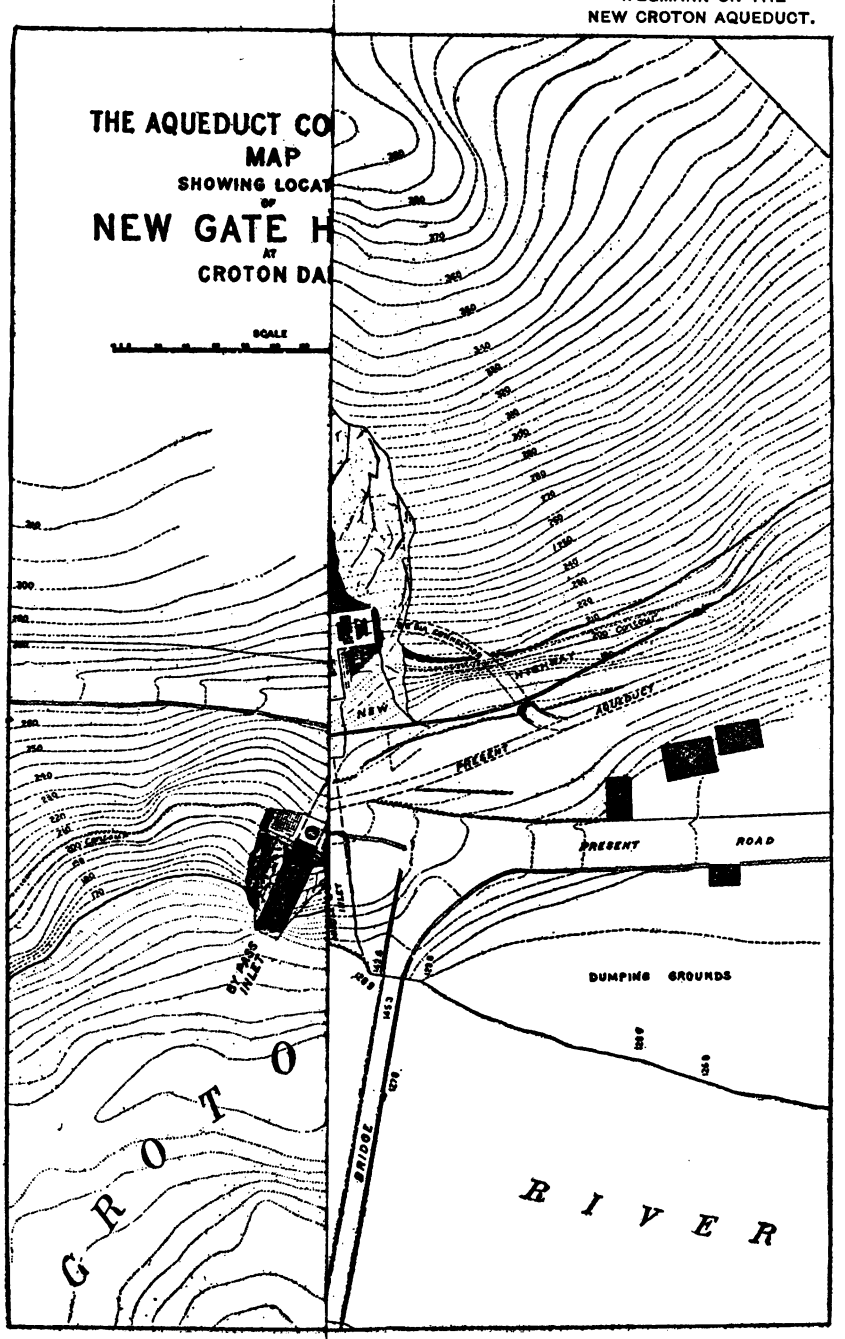
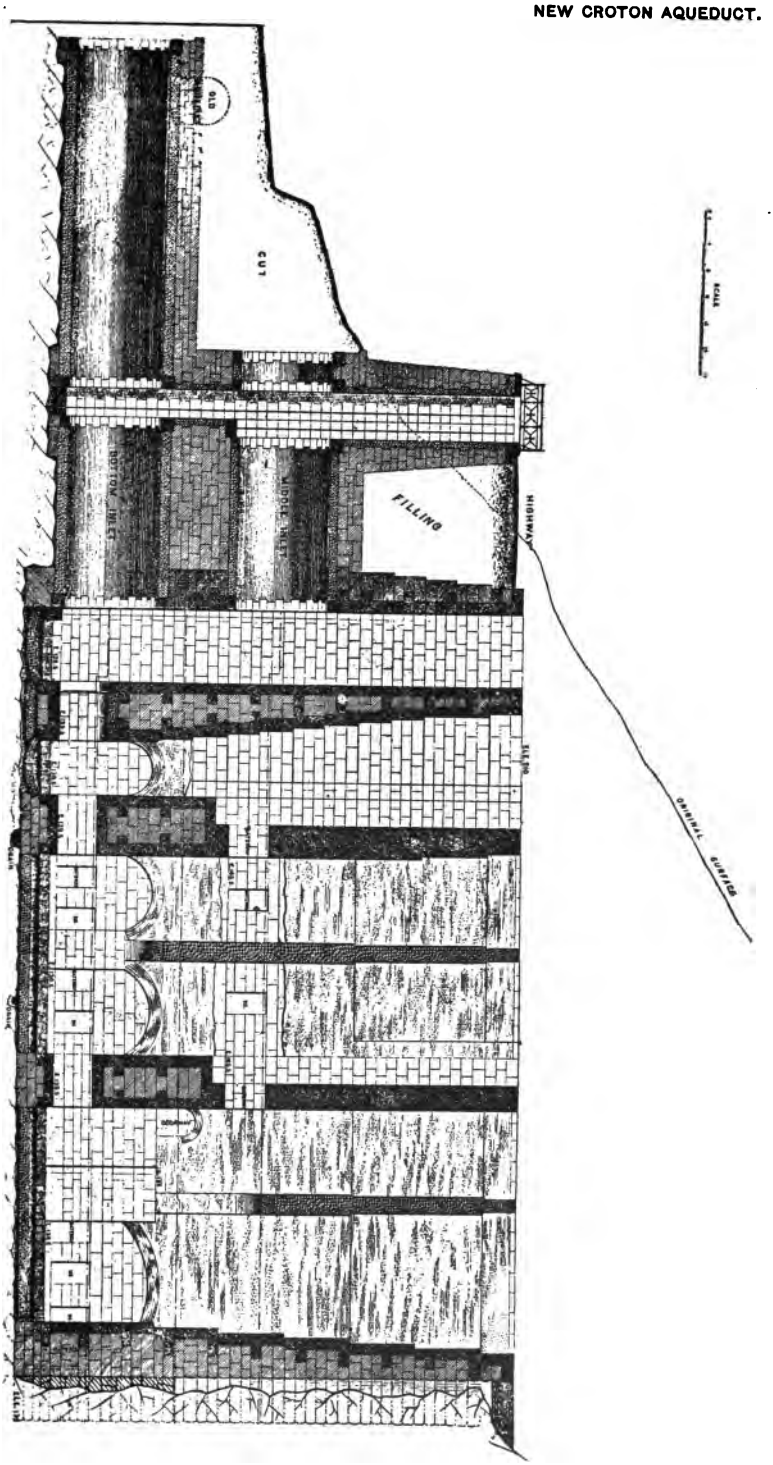


PLATE XIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.



NEW CROTON GATE-HOUSE.

100 ft. below the surface, but the water, when admitted, has sufficient head to rise about 30 ft. above the surface. Fears were entertained that the water might find some open seams in the rock and flood the cellars of houses near by. For this reason it was decided to line the Aqueduct at this place for 234 lin. ft. with iron rings 1 in. thick, which were constructed as shown in Plate XI.

The rings were made with "hub and spigot joints," which allowed some play in fitting them together. The longitudinal joints of the iron-work were made with lead gaskets and also with a filling of a rust-joint (iron filings mixed with sal ammoniac and water). The circumferential joints were only filled with Portland cement mortar.

The iron lining was backed with 18 in. of brick-work and then with rubble masonry to the solid rock. The backing masonry was finally thoroughly grouted through holes which had been provided in the iron lining and which were closed by means of plugs.

The flow through the new Aqueduct is controlled by means of the following gate-houses:

1st. The New Croton Gate House, forming the inlet at Croton Lake.

2d. The One Hundred and Thirty-fifth Street Gate House, forming the terminus of the masonry conduit.

3d. The Central Park Gate House, controlling the discharge into the Central Park Reservoir.

4th. Three "overflow and blow-off gate-houses," located respectively at the Pocantico River, at Ardsley and at South Yonkers.

5th. Two blow-off vaults; one located at Shaft No. 24 on the east side of the Harlem River and the other at Shaft No. 25 on the west side of this river.

The inlet gate-house (Plate XII) was located on a rocky side-hill, south of the Croton River, about 250 ft. below the Old Croton Dam. To provide the space required for this structure an area of about 90 by 100 ft. had to be excavated to a depth of 90 to 160 ft. The highest slope-stakes were about 210 ft. above the bottom of the excavation.

Plates XII and XIII show the general arrangement of the substructure of the gate-house, the walls of which have a height of about 70 ft. It is provided with five different inlets with a view of

producing circulation in the reservoir by draining the water from different points and levels. A circular by-pass inlet having an inner diameter of 14 ft. and a length of 624 ft. connects the gate-house with Croton Lake. It has been the only available means of putting the Aqueduct into service during the construction of the New Croton Dam. This inlet enters the substructure of the gate-house at its southeast corner, near the bottom. A surface inlet enters the substructure above the by-pass. On the east side of the gate-house there are a bottom and, also, a middle inlet, one above the other. The last three inlets mentioned are short circular conduits 14 ft. in diameter.

A fifth circular inlet, having a diameter of only 8½ ft., enters the gate-house on the north side of the substructure. It is connected with the Old Croton Aqueduct and can serve either for drawing water through this Aqueduct from the reservoir near the New Croton Dam or as an outlet for supplying the Old Croton Aqueduct.

The new Aqueduct begins at the southwest corner of the gate-house with an invert grade of 140 (Croton Datum). As the elevation of high-water in the reservoir is 200, there are 60 ft. of water available for storage.

The new Aqueduct was not designed to be under pressure as far as the Jerome Park Reservoir. When the reservoir is full the pressure of the 60 ft. of head is overcome by letting the water pass through a series of three or four sets of 3 x 6 ft. sluice gates, placed in the cross-walls of the substructure. There are in all 42 of these sluice-gates.

Plate XII shows the number of water chambers into which these cross-walls subdivide the substructure. Screens are placed in the chamber, where the new Aqueduct leaves the gate-house. A drainage system of pipes and a small turbine and pumps are provided for emptying the different water-chambers, each of which can be separated from the others by means of stop-planks.

The construction of the One Hundred and Thirty-fifth Street Gate House is shown on Plates XIV, XV and XVI. The water from the new Aqueduct flows up a vertical well into the main water-chamber of the gate-house, from which it can be admitted into the eight lines of 48-in. mains, laid down Convent Avenue. Each

FIG. 1.—GATE-HOUSE AT 135TH STREET.

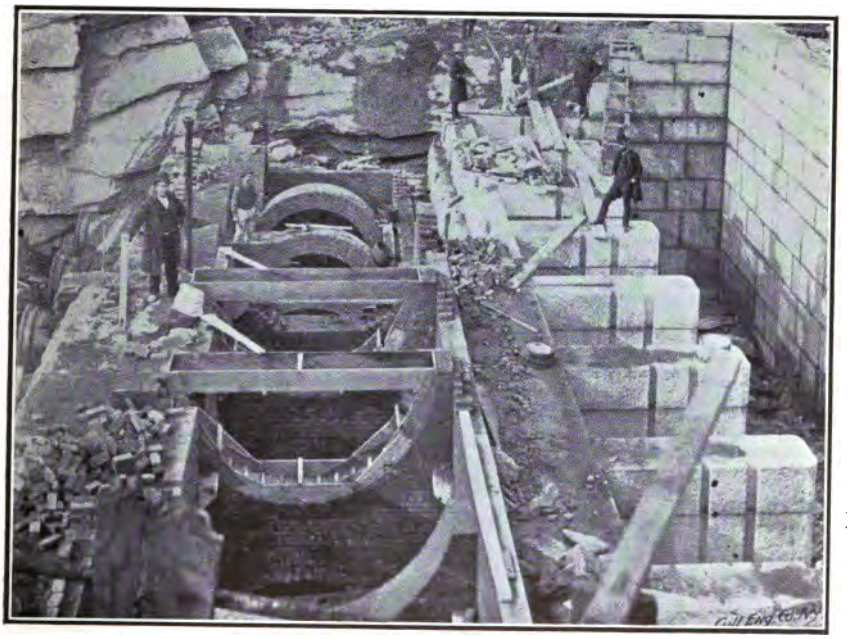
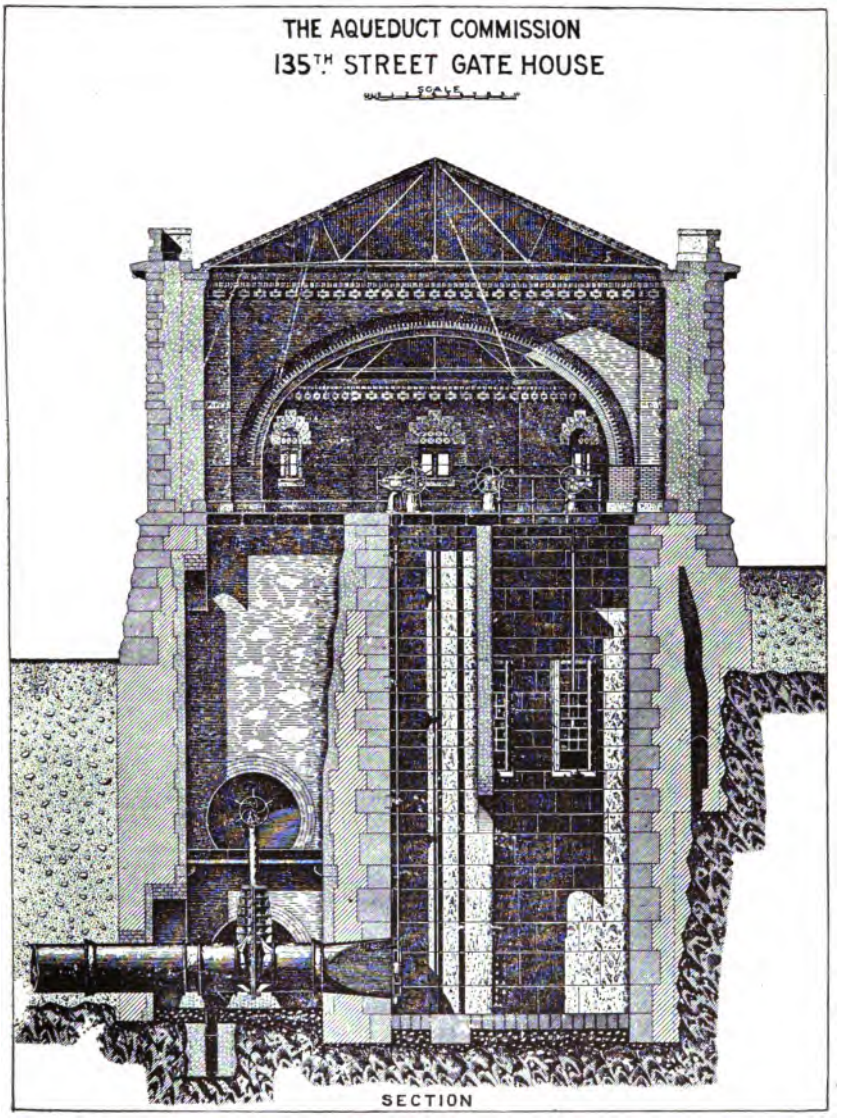
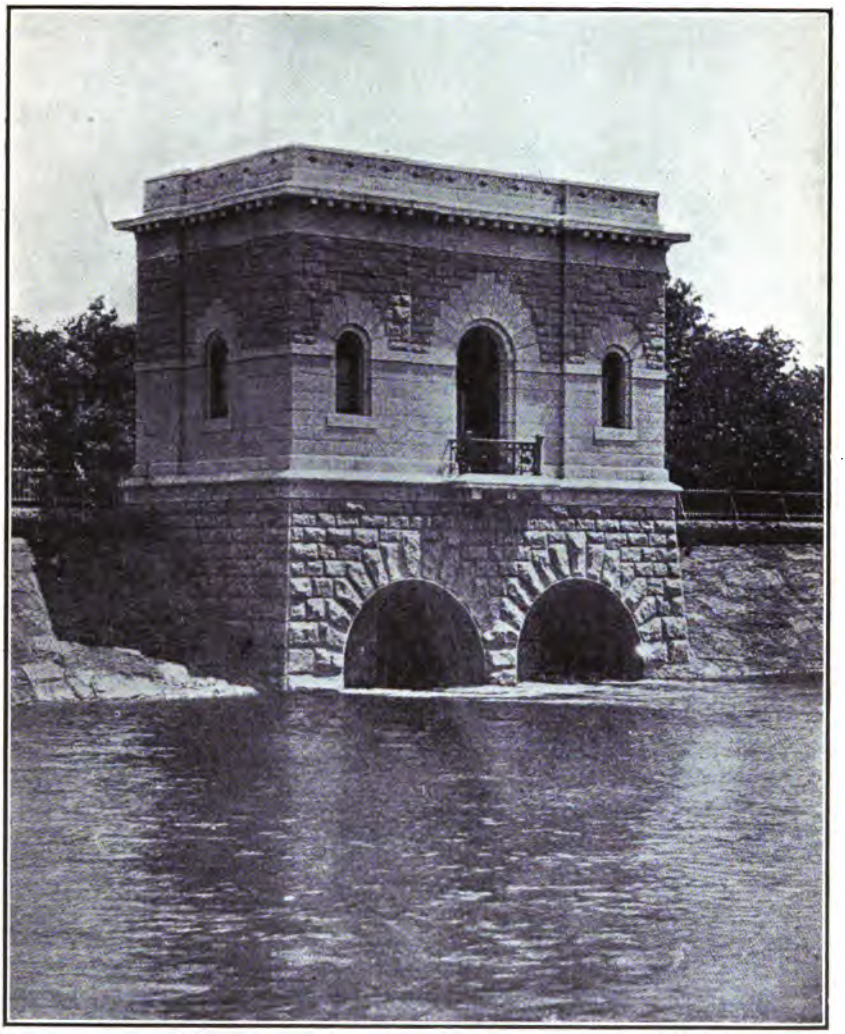


FIG. 2.—135TH STREET GATE-HOUSE IN CONSTRUCTION.

PLATE XV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.


THE AQUEDUCT COMMISSION
135TH STREET GATE HOUSE
SECTION



CENTRAL PARK GATE-HOUSE.

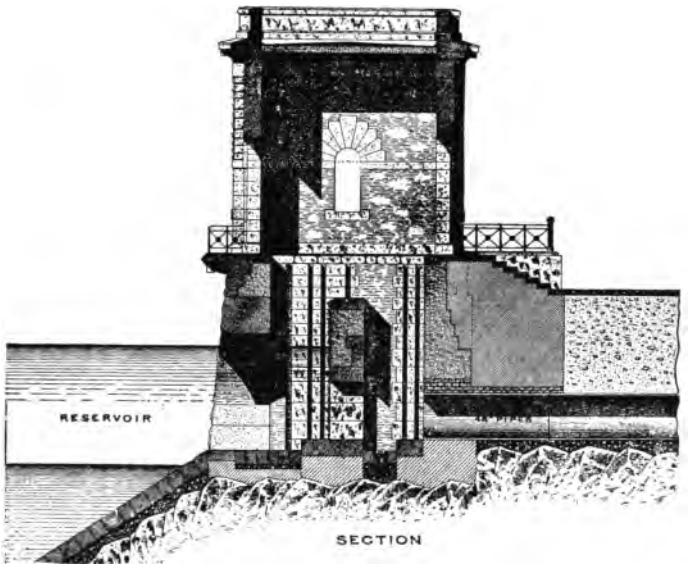


FIG. 1.—CENTRAL PARK GATE HOUSE.

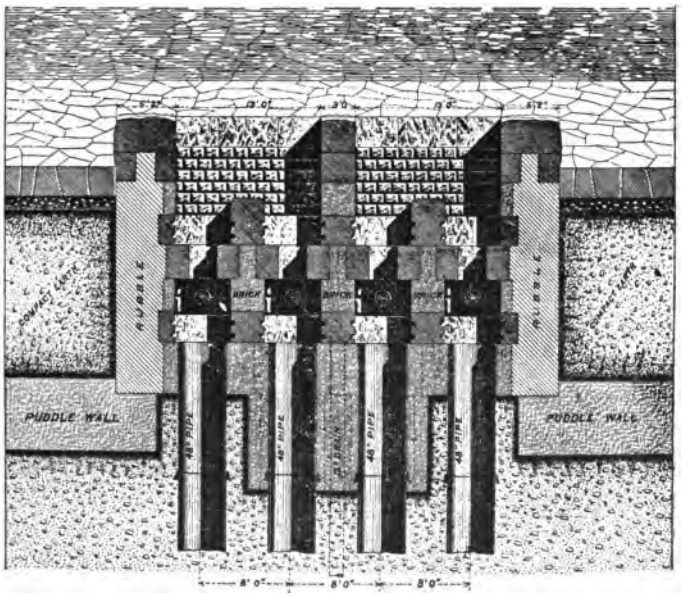


FIG. 2.—PLAN—CENTRAL PARK GATE HOUSE.

PLATE XIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.

THE AQUEDUCT COMMISSION

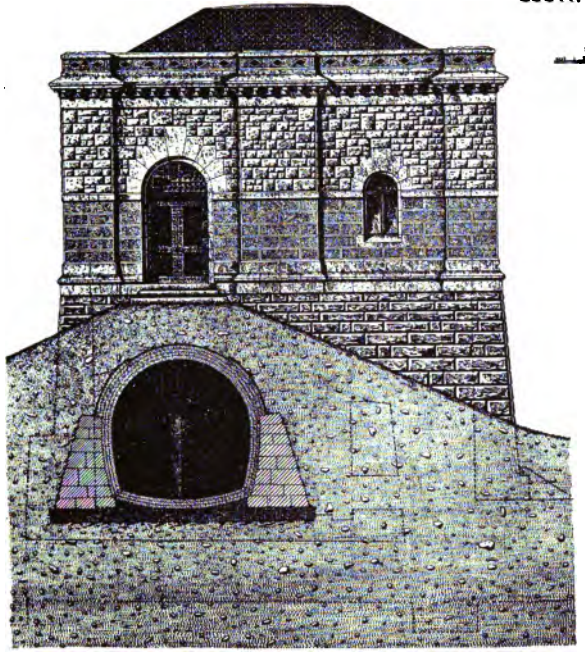
BLOW-OFF AND WASTE WEIR

AT

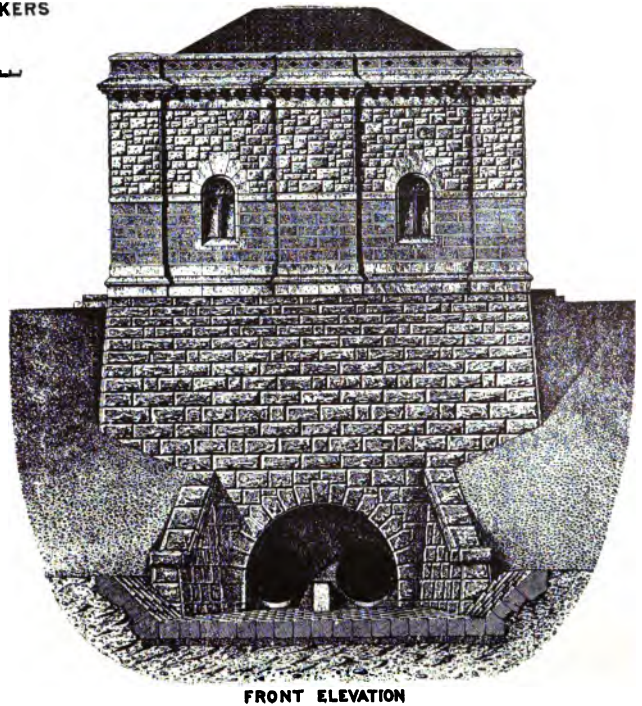
SOUTH YONKERS

N.Y.

SCALE



END ELEVATION



FRONT ELEVATION

of these pipe-lines has a separate chamber in the gate-house which can be closed from the main chamber by two sets of stop-planks, for which grooves are provided in the side walls of the pipe chamber. Besides the stop-planks, each pipe-line is provided with a 2 x 5 ft. sluice-gate and with a stop-cock.

The Old Croton Aqueduct, which is constructed in Amsterdam Avenue, near the gate-house, is connected by a short conduit with the gate-house, on its west side, as shown on Plate XV. Four lines of 48-in. mains form the outlet into the Old Aqueduct, which crosses Manhattan Valley by four lines of pipes.

From what has been said above it will be seen that the One Hundred and Thirty-fifth Street Gate House controls the flow both of the New and of the Old Aqueducts.

The Central Park Gate House (Plates XVII and XVIII) is a comparatively simple structure, which controls the discharge of four lines of the new 48-in. mains into the Central Park Reservoir. Each pipe-line can be closed by a 2 x 5 ft. sluice-gate or by stop-planks.

The three overflow and blow-off gate-houses are all constructed according to the same general plan, which may be illustrated by the South Yonkers Gate House (Plate XIX). The main water-chamber is divided by a central pier into two outlets, each of which can be closed by stop-planks. On one side of this water-chamber a side-wall is constructed having its top somewhat below the usual water-level. It is subdivided by three piers into four short overflows, the height of which can be regulated by means of stop-planks, for which grooves are provided. The water passing over these overflows is conducted by means of a culvert into a neighboring brook. Four openings are constructed in the side-wall of the main water-chamber, mentioned above, near the bottom, and are controlled by sluice-gates. They are the "blow-offs" and serve for emptying that part of the Aqueduct between the "overflow and blow-off" gate-house and the next similar gate-house, on either side, when required for inspection or repairs. Before this is done, stop-planks are placed between the side-walls of the main water-chamber and the central pier, mentioned above, in the two gate-houses between which the conduit is to be emptied. This particular section of the Aqueduct is thus cut off from the rest of the conduit. If it

were not for this arrangement, the whole Aqueduct would have to be emptied whenever any particular part might need repairs, which would involve a waste of water and a loss of time in refilling the Aqueduct.

The blow-off vaults at Shafts Nos. 24 and 25 (see Plate X) serve for emptying the Aqueduct under pressure between Mosholu Avenue at Jerome Park and the One Hundred and Thirty-fifth Street Gate House, with the exception of the siphon under the Harlem River, which is emptied by pumping as described hereafter.

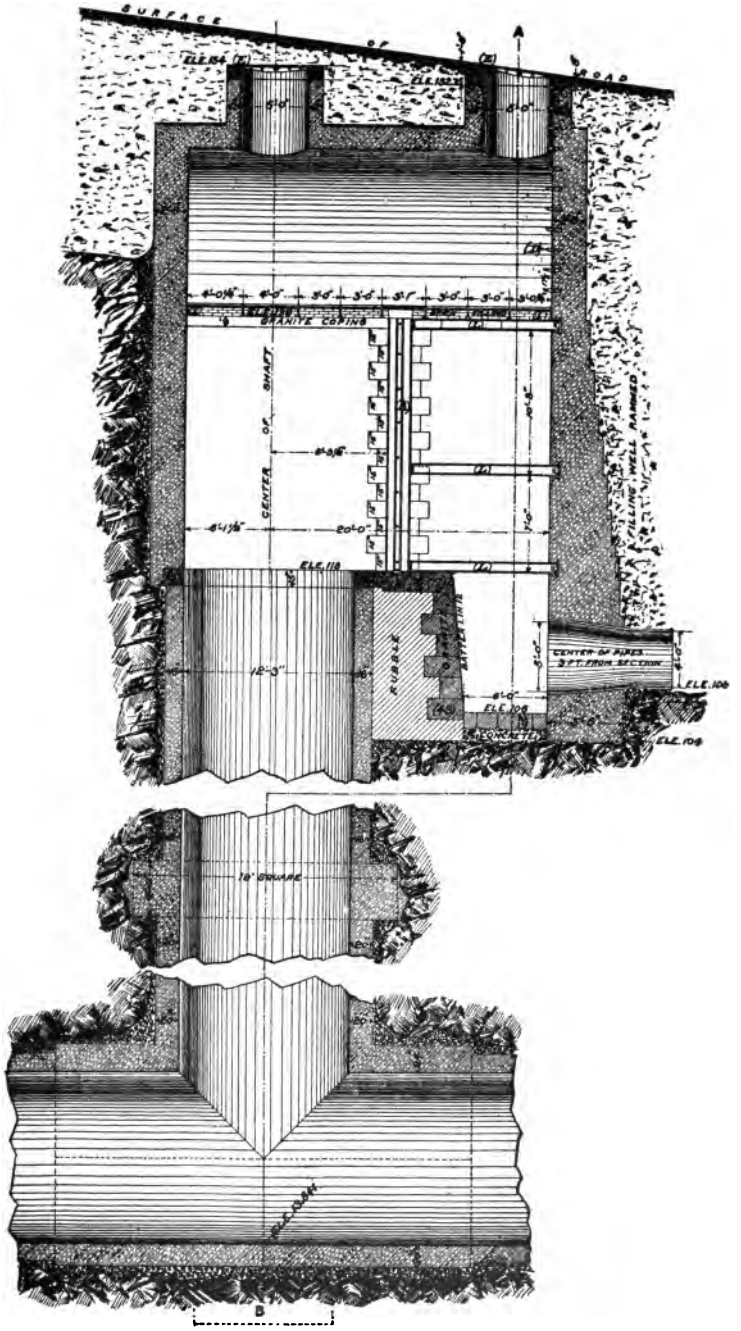
The blow-off at Shaft No. 24 consists of a 30-in. pipe which is enlarged to a 36-in. pipe which is laid to the Harlem River. This pipe-line is connected with Shaft No. 24 and is controlled by stop-cocks placed in a suitable vault.

The blow-off at Shaft No. 25 consists of two lines of 48-in. pipes, which are connected with this shaft and are laid through a small drift to the Harlem River. Each of these pipe-lines is controlled by two stop-cocks, one placed back of the other, so that if one should fail the other could be put into service. A vault is built over the stop-cock.

The pumping plant erected originally for emptying the siphon under the Harlem River consisted of two bailing buckets, each 4 ft. in diameter and 14 ft. deep, having a capacity of 1 390 gal., which were alternately lowered to the bottom of the pump-well of Shaft No. 25 and raised by a powerful hoisting engine. Each of the buckets had a flap-valve at the bottom, opening upwards, which permitted the water to enter as the bucket was being lowered and closed as it was being hoisted. A sliding gate placed in the side of the bucket, near the bottom, served for discharging the water. It was connected by rods with a trip-bar, fastened to the top of the bucket. When the bucket reached the point where the water was to be discharged, a post, placed in the side of the pump-well, "tripped" the bar and thus raised the discharge gate of the bucket. The water was emptied into a catch-basin, from which it was conveyed through the blow-off pipes into the Harlem River.

Yellow-pine guides (6 x 8 in.) were provided in the pump-well for each bucket. The pump-well is connected at the bottom with

PLATE XX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
WEGMANN ON THE
NEW CROTON AQUEDUCT.



SECTION AT CENTER

SHAFT No. 26.

the Aqueduct well by a bronze gate which is operated from the top of the shaft.

The method of emptying the siphon under the Harlem River by the bailing buckets, while simple, consumed about 30 hours each time. In 1902 and 1903 the bailing apparatus and hoisting engine, etc., were replaced by a pneumatic plant furnished by the Pneumatic Engineering Company of New York, which is capable of pumping 2 500 000 gal. 337 ft. high in 12 hours. This plant has been fully described by Mr. A. H. Diamant, C. E., in the *Transactions* of the American Society of Civil Engineers for 1904.

The bluff on which Shaft No. 25 is located is below the hydraulic grade-line of the Aqueduct. On this account both the Aqueduct well and the pump-well of the shaft had to be closed by suitable man-hole covers, of which two sets were provided.

Shaft No. 26, located 525 ft. to the west of Shaft No. 25, on the east side of Amsterdam Avenue, rises above the hydraulic flow-line and had not to be closed. This shaft was arranged so as to form an overflow for the Aqueduct, as shown in Plate XX. The height of the overflow-weir can be regulated by stop-planks and two lines of 48-in. overflow-pipes convey the waste water to the Harlem River.

When the New Croton Aqueduct was designed, there was some uncertainty in calculating what its maximum discharging capacity would be, as no gaugings of flow had been made, at the time, on so large a conduit. Records of discharge were available for the Sudbury Aqueduct of Boston, but this conduit was only 7 ft. 8 in. high by 9 ft. wide. The experiments made on this Aqueduct were plotted and used to estimate what the maximum flow through a circular conduit of 14 ft. inner diameter might be.

In the preliminary calculations the maximum flow in a circular conduit was assumed to occur when the conduit is full, although, as explained before, a somewhat greater discharge will occur when the water-surface in the conduit subtends an angle of 52° at the top of the arch.

The following general formula was used in calculating the discharge of the Aqueduct:

$$D = v \times a \times 7.4805 \times 86\,400 \qquad (1)$$

in which

D = discharge, in gallons per 24 hr.;

v = mean velocity, in feet per second;

a = area of water channel, in square feet.

7.4805 gives the gallons in a cubic foot and 86 400 gives the number of seconds in 24 hr.

The only unknown quantity in Equation (1) is v. It was calculated by the following empirical formulas:

The Chezy Formula.

$$v = c\sqrt{r\,s} \qquad (2)$$

in which

c = a constant found by experiment;

r = mean hydraulic radius = $\dfrac{\text{area of water channel}}{\text{wetted perimeter}}$;

s = sine of slope = $\dfrac{\text{total fall}}{\text{total length}}$.

The experiments made by Fteley and Stearns in the Sudbury Aqueduct* give values of c for values of r varying from 0.5 to 2.33 ft. c is found to vary direct with r. Plotting the experiments just mentioned, taking the c's as ordinates and the r's as abscissas, the curve obtained is found to become almost a straight line for the higher values of r.

Producing this line, the value of c corresponding to $r = 3.5$ (the mean hydraulic radius of a circular conduit of 14 ft. inner diameter, flowing full) is found to be 141.6.

Substituting this value of c in the Chezy formula, and the resulting value of v in Formula (1), we obtain:

D = 318 777 000 U. S. gal. for the conduit flowing full.

(3.) *The Kutter Formula.*

$$v = \frac{41.66 + \dfrac{1.811}{n} + \dfrac{0.00281}{s}}{1 + \left(41.66 + \dfrac{0.00281}{s}\right)\dfrac{n}{\sqrt{r}}}\sqrt{r\,s} \qquad (3)$$

In this formula v, r, and s have the same significations as in Formula (2), n is the coefficient of roughness which is found by

* See *Transactions* of the Am. Soc. C. E. for 1883.

experiment. For good brickwork Kutter gives $n = 0.013$. Substituting this value of n in Equation (3) and the resulting value of v in Equation (1), we find:

$$D = 323\,257\,000 \text{ U. S. gal.}$$

The Kutter formula as used above equals the Chezy formula with $c = 143.59$.

The Bazin Formula.

$$A\,v^2 = r\,s.$$

From which we obtain—

$$v = \frac{1}{\sqrt{A}}\sqrt{r\,s} \qquad (4)$$

in which v, r and s have the same significations as in the preceding formulas.

M. Bazin gives the following of A, based upon his experiments:

For very smooth walls $A = .000046\left(1 + \frac{0.10}{r}\right)$.

For fairly smooth walls $A = .000058\left(1 + \frac{0.23}{r}\right)$.

Using the first of the above values of A we obtain—

$$D = 327\,873\,000 \text{ U. S. gal.}$$

For the second value of A we find—

$$D = 287\,484\,000 \text{ U. S. gal.}$$

Dr. Lampe's Formula.

$$v^{1.8} = \frac{s\,r^{1.25}}{K},$$

in which all dimensions are taken in meters.

v = velocity, in meters per second;

K = a constant found by experiment. s and r have the same significations as in the preceding formulas.

Mr. Lindley's experiments in the sewers of Frankfort-on-the-Main gave—

$$K = 0.00019.$$

Using this value and English measure Lampe's Formula becomes—

$$v = 167.89\,r^{0.694}\,s^{0.555}.$$

Substituting the value of v found by this formula in Equation (1), we find—

$$D = 302\,872\,000 \text{ U. S. gal.}$$

After the New Croton Aqueduct had been put into service in July, 1890, careful gaugings were taken with a current meter to find its daily discharge for different depths of water. The maximum discharge was found to be about 302 500 000 U. S. gal., which agrees very closely with the preliminary estimate made by means of Dr. Lampe's formula.

The gaugings were made with a small current meter, made by Buff and Berger, of Boston, at a special manhole, constructed about 1 000 ft. south of the Yonkers Gate House to give access to the Aqueduct. It was fitted with a special apparatus which made it possible to hold the current meter in every square foot of the "wetted area" and to read the velocity. From these observations the average velocity for the whole wetted area was obtained.

No further gaugings were made until the latter part of 1899, when Mr. F. W. Watkins, C. E., who had made the original gaugings, took current-meter measurements at the special manhole mentioned above with the same instrument he had used in 1890. These observations were made at the request of Mr. John R. Freeman, M. Am. Soc. C. E., who was making a study of the condition of the water supply of New York for the Comptroller, Mr. Bird S. Coler.

The gaugings of 1899 showed a diminution in the delivery of the Aqueduct of 16%, compared with the flow in 1890. This difference was partly due to the fact that the safety grating at the head of the siphon at Gould's Swamp was badly obstructed by leaves and twigs, but even after this grating had been cleaned the flow through the Aqueduct was considerably less than in 1890. This difference is very probably due to the fact that the lining of the conduit has become coated with slime and probably, also, with a growth of *spongila,* in the first five miles or more of the Aqueduct.

Observations made on the Sudbury and Wachusett Aqueducts of Boston prove that the coating of slime and *spongila* formed on their inner surfaces reduced the delivery of water about 10% in a year's time. To avoid this loss the inner surfaces of these Aqueducts

are thoroughly cleaned with bamboo brushes once or twice each year. After this cleaning the delivery is restored to its original quantity.

Owing to the great increase in the consumption of water in New York it has been impossible during the past 13 years to empty the New Croton Aqueduct for inspection and cleaning.

The writer has endeavored to give in this paper a general description of the New Croton Aqueduct. To enter into all the details of this work and its appurtenances would expand this paper almost into a book and would require the reproduction of a great many drawings. At some later period the writer hopes to be able to give a description of the new reservoirs that have been constructed in connection with the New Aqueduct.

Before concluding the engineers will be mentioned who were at the head of the engineer department of the Aqueduct Commissioners during the construction of the New Croton Aqueduct.

On August 15, 1883, the Aqueduct Commissioners appointed Mr. B. S. Church as their Chief Engineer. He had been in charge of the Old Croton Aqueduct as Resident Engineer for many years.

On January 23, 1884, the Commissioners appointed Mr. Alphonse Fteley as Principal Assistant and Executive Engineer and Mr. H. S. Craven as Engineer of Construction.

Mr. Fteley had been Resident Engineer in charge of the construction of the Sudbury Aqueduct, of Boston. His title was changed by the Aqueduct Commissioners in May, 1885, to that of Deputy Chief Engineer and in July, 1886, Mr. Fteley was appointed Consulting Engineer.

Mr. J. P. Davis, City Engineer of Boston from November, 1872, to March, 1880, was engaged as Consulting Engineer by the Aqueduct Commissioners from April, 1884, to July, 1886.

In November, 1888, Mr. Church and Mr. Fteley exchanged positions, the former becoming the Consulting Engineer of the Aqueduct Commission and the latter the Chief Engineer.

The New Aqueduct was completed, and most of the new reservoirs were either finished or well advanced under Mr. Fteley as Chief Engineer.

DISCUSSION.

MR. MYRON H. LEWIS, Member of the Society.—Mr. President and Gentlemen, while the author's paper does not treat directly of the New Croton Dam, I think it would interest the members to have the author tell us something about the tearing up of the core-wall portion of the dam and replacing it by a full masonry section. The great amount of discussion aroused when the change was contemplated, the difficulty in securing a satisfactory foundation for this new portion, the increase in the cost and the delay in the completion of the dam are all matters upon which the author could enlighten us.

THE AUTHOR.—I had not intended to discuss the New Croton Dam to-night, as it is a large subject in itself. As regards the necessity of substituting a solid masonry dam for that part of the dam which, according to the original plans, was to consist of an earthen bank with a masonry core-wall, I would say that engineers often differ in opinion just as doctors disagree. Mr. A. Fteley, the designer of the dam, felt satisfied to found a core-wall for an earthen dam on limestone that could be worked with a pick, when he would not have accepted such rock for the foundation of a masonry dam. In the case of the earth dam, the embankment was only about 50 ft. high above the surface of the ground, while the trench for the core-wall was sunk to such a depth that this wall had a maximum height of 175 ft. Considering the great width of the base of the earthen dam and the great depth of the trench of the core-wall, it seems very improbable that any great percolation would have occurred through this bank.

Some cracks were found in the core-wall, but similar cracks occurred, also, in part of the masonry dam that was founded on solid rock. Such cracks occur in all long pieces of masonry and are due to expansion and contraction in the masonry. Similar cracks are found in a camparatively low core-wall at the Jerome Park Reservoir that was founded on rock.

A board of expert engineers who examined the New Croton Dam in 1901, at the request of the Aqueduct Commissioners, recommended that a masonry structure be substituted for the earthen dam with masonry core-wall, in order to insure absolute security against disaster. While I think the dam would have been safe if constructed according to the original plans, I would have designed the dam entirely of masonry, on account of its importance.

The extra cost of tearing down the core-wall and replacing the earthen bank by a masonry dam was estimated at about $500 000. The New Croton Gate House that controls the inlet to the New Aqueduct at Croton Lake cost about $1 000 000. Mr. Robert Ridg-

way, who was the Assistant Engineer in charge of this work, is present to-night and can give us some details about the construction of this gate house.

MR. ROBERT RIDGWAY, Member of the Society.—I cannot add much to what the author has said, except to state that about 125 000 cu. yd. of rock excavation was required for the gate house. The cut was made into the side of a steep hill, and the vertical height from the bottom of the excavation to the surface of the ground at the back of the cut was something over 200 ft. The gate chambers were 70 ft. deep. The concrete backing for the lower walls of the chambers was carried back to the rock of the excavation. The cost of the substructure was about $750 000. The number of sluice gates to be provided when the gate house is in full operation is, I think, between forty and fifty.

MR. GEORGE J. BISCHOF, Member of the Society.—I have been reading so much about the loss of water through leakage that I should like to know if there is anywhere near the percentage of loss that some of the newspapers are trying to make us believe.

THE AUTHOR.—Whatever loss there may be by leakage from the Aqueduct is more than offset by the infiltration of ground water. About 4 000 000 gal. per day are added in this way to the supply drawn from Croton Lake.

A great deal of water is wasted in the City by leaky mains and defective plumbing. In cold weather much water is wasted by people leaving the faucets open to prevent the water from freezing in the pipes.

MR. WILLIAM D. LINTZ, Member of the Society.—To the best of my recollection there has been only one serious break on the lines of 48-in. pipe laid by the Aqueduct Commission from the One Hundred and Thirty-fifth Street Gate House south. That occurred last year a short distance south of gate-house on Convent Avenue. The lines at this point have about 25 ft. of covering on them; after excavating down to the pipe one of them was found to be cracked and this was replaced. As to the cause: the supposition was that the general settlement of this deep trench caused the break. During the excavation, some very heavy stone were found over the pipe; but it is hardly fair to imply that they were placed there. They may have fallen in from the sides of the trench after the break occurred, as the great quantities of escaping water carried out all the loose earth in the neighborhood of the break, and naturally the stone would settle down. As this is the only serious break which has occurred on these lines after about fifteen years of service, much credit is due to the engineers and inspectors connected with the work.

THE AUTHOR.—There is another case where a little leakage

occurred in one line of the pipes laid on Convent Avenue for the New Aqueduct. In this case, the pipes had been undermined for the construction of a retaining wall. It is, therefore, not surprising that some leakage occurred as the pipes probably settled a little on account of the undermining.

MR. LINTZ.—It might be interesting and pertinent to the subject under discussion if Mr. Wegmann would tell us if the water has been turned on the New Croton Reservoir behind the new dam.

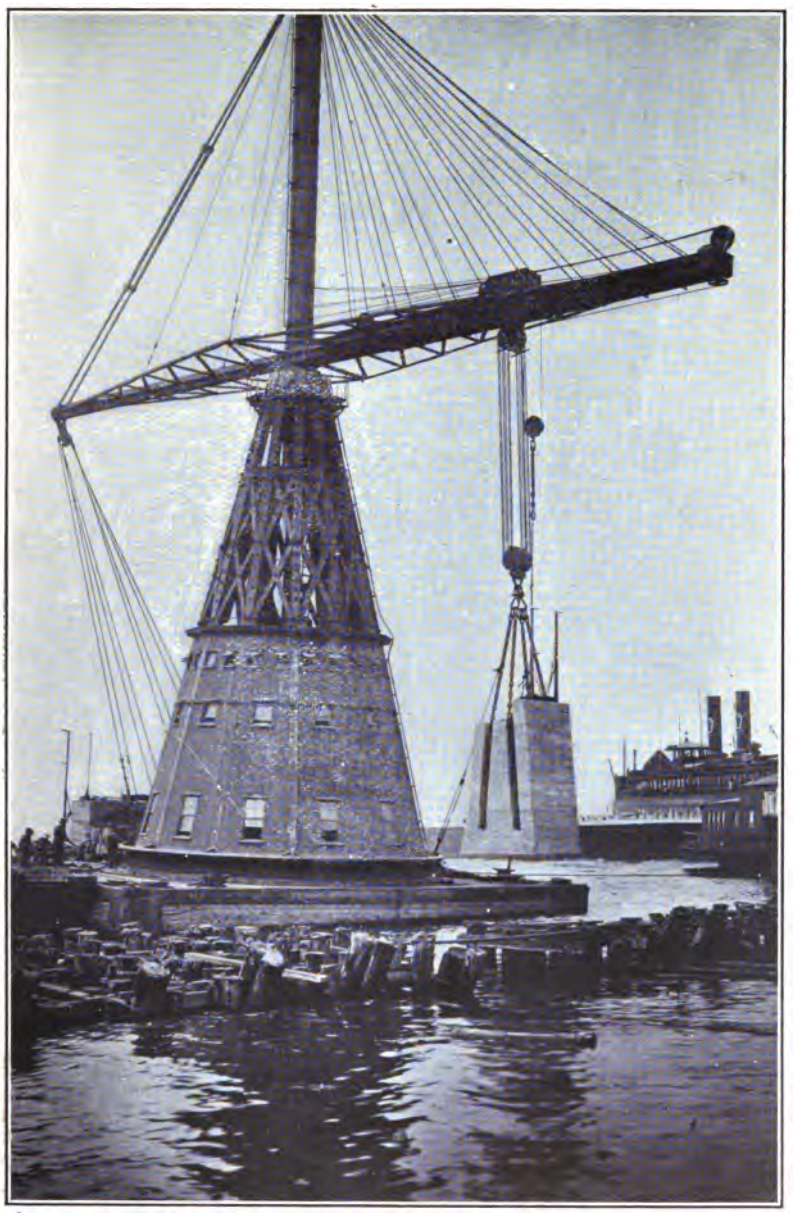
THE AUTHOR.—The reservoir is filling slowly, the depth of water being at present about 35 ft.

Two arched openings were constructed in the New Croton Dam at the level of the original river-bed. One of these openings served as a temporary channel for the river and the other was used by the contractors for transporting materials from one side of the dam to the other. During floods both openings were filled with water.

The two openings have been filled with concrete and grouted by perforated gas pipes that were placed in the masonry. The depth of water above the openings when the reservoir is full will be about 100 ft.

It would be difficult to estimate how long it will take to fill the New Croton Reservoir. I should not like to make a guess on this point.

In designing a masonry dam the pressures to which the masonry is subjected must be kept within certain safe limits. When the plans were made for the New Croton Dam, about twenty-one years ago, no approved precedent could be found for exposing the masonry of a dam to greater pressure than 6-8 tons per square foot, which is the limit of pressure adopted for the highest existing dams. There was one dam in Spain about 300 years old (known as the Almanza Dam) in which the pressures in the masonry reached 14 tons per square foot, but this dam had not been designed on scientific principles. If the pressures in the masonry of the New Croton Dam had been limited to 6-8 tons per square foot the base of the dam would have had a width of about 300 ft., which would have increased the cost of construction very much. The dam was designed for a limiting pressure of 16 tons per square foot, which good masonry can stand safely, the base of the dam having a width of about 216 ft.



ONE HUNDRED TON DERRICK "CITY OF NEW YORK."

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 16.

PRESENTED MARCH 22D, 1905.

THE DOCK DEPARTMENT AND NEW YORK DOCKS.

BY SIDNEY WILLETT HOAG, JR.,* B. S., Member of the Society.

WITH DISCUSSION BY
HORACE R. HOWE, SAMUEL C. THOMPSON, STEPHEN U. HOPKINS, WISNER MARTIN, JOHN C. WAIT, LAZARUS WHITE, TYRRELL B. SHERTZER, WILLIAM J. DUNCAN, MARTIN J. BROWNE AND THE AUTHOR.

In presenting a discourse on this topic to the Society, it seems almost indispensable to briefly review the principal historical events leading up to the present title of the City of New York to what is probably its most valuable property, the water front and land under water around Manhattan Island. When Hendrik Hudson, in September, 1609, struck anchor in the Horse-Shoe at Sandy Hook and proceeded up the Bay into the North River, he must have been elated when he beheld the magnificent natural conditions surrounding this unknown harbor in all its primitive splendor, which destined it to undergo those metamorphoses which have contributed towards making it the greatest port and commercial center on the Western Continent. These natural conditions seem to have made the greatness of New York inevitable, for during the period of its development it was without a rival. At the present day, however, through the operation of great inland transportation facilities, a number of competitors for future supremacy have appeared upon the commercial horizon, and this fact, taken in connection with the increasing difficulties attending the maintenance of an adequate harbor entrance for vessels of deep draught, should be the inspiration and

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incentive to extraordinary activity and superior wisdom on the part of our local authorities, as well as the Federal Government, to preserve and retain with jealous fervor the position which we have attained. For all of our natural advantages would avail but little against the combined discrimination of trunk lines and steamship companies in favor of some other port or ports. Our policy must be one calculated to allure, to win and to hold the steamship companies. With that accomplished, the remainder of the problem is not so difficult to handle, for the ocean-going steamships demand, yea, *they must have* an adequate port of entry and adequate wharfage accommodations for the reception and transmission, the loading and unloading of freight, together with sufficient and convenient facilities for land transportation. The progress of the present decade is moving with the strides of a mammoth, and we are rapidly approaching a period when conservatism must yield to radical treatment in conformity with the law of self-preservation.

History of the City's Title to the Water Front.

In the early part of the Seventeenth Century the Dutch West India Company, in 1623, received from the Dutch States General a grant of all the lands situated on the island of Manhattan. This company extinguished the Indian title by purchase from a tribe of aborigines, called the Manhattoes, for the sum of 60 guilders. During the Dutch occupancy, all titles on Manhattan Island emanated from the Dutch West India Company.

In 1664, the English came in possession of Manhattan Island and the surrounding country, and on March 12th Charles the Second granted to the Duke of York the territory of New York, New Jersey and all the appurtenant rivers, harbors, lakes, waters, etc., with all the rights, royalties, profits and all the royal estate and interest, with power to govern the inhabitants, according to such laws, ordinances, etc., as the Duke might establish.

In 1665, the English governor, Nicoll, representing the Duke of York, revoked the old Dutch form of government, and on July 12th established the city government under a Mayor, Aldermen and Sheriff.

The Dongon Charter.—The Doctrine of the common law at that time was that the King was the owner and source of title to all

lands in his dominion. Lieutenant-Governor Thomas Dongon, administering the Colonial Government under James the Second, on April 12, 1686, granted a charter to the Mayor, Aldermen, etc., which transferred to the latter "All the waste, vacant, unpatented "and unappropriated land within the city and island, extending "and reaching to low water mark in, by and through all parts of the "city and Manhattan Island, together with all rivers, rivulets, coves, "creeks, ponds, waters and water courses therein not theretofore "granted by former governors or other properly constituted authori- "ties of said city to some respective person or persons." By this charter the city limits were established at low water mark around Manhattan Island. It must be noted that this charter proceeded from Governor Dongon individually, and not directly from the Crown; but it was subsequently confirmed and extended by the Montgomerie charter hereinafter described.

The Cornbury Charter.—On April 19, 1708, Queen Anne, through Governor Cornbury, granted a charter in response to a petition by the Corporation of New York for the confirmation of what it considered to be its vested rights under former charters in and to a certain ferry between the city and Long Island called "the old ferry;" and it granted to the City of New York, in the language of the charter, "a ferry from Nassau or Long Island over the East River "to the city on both sides of the said river, and also all the vacant "and unappropriated grants from high to low water mark on said "Nassau Island from a certain place, called the Wallabout, unto the "Red Hook, that is to say, from the east side of Wallabout opposite "the dwelling of James Robine to the west side of the Red Hook, "commonly called the Fishing Place, with all appurtenances, rents, "issues and all the estate, right, interest, benefits, advantages, claims, "etc., of the Crown in said ferry, vacant land and premises," with a reservation allowing the Brooklyn inhabitants to transport their own persons, goods, etc.

The area between high and low water mark along the Brooklyn shore, thus conveyed, extended from about South Tenth Street in what was formerly Williamsburg to Red Hook, or the Atlantic Basin.

The Montgomerie Charter.—This charter was granted by George the Second on January 15, 1730, through the Provincial Governor, John Montgomerie. It confirms the previous grants made under

the Dongon and Cornbury charters, and further granted the land under water on the North River to a line 400 ft. from low water mark between Bestaver's Killitie (at about between Charles and King Streets) and the south side of the street (formerly Market Field, afterwards Battery Place), which ran from the Parade ground in front of the old fort to the Hudson River. The site of the old fort is now occupied by the new Custom House. Also on the East River, the land under water for a width of 400 ft. outside of low water mark, between Whitehall Street and the north side of Corlears Hook, between Stanton and Houston Streets.

This charter also authorizes the Common Council to establish as many ferries around the island of Manhattan to opposite shores as it may see fit, and to let or otherwise dispose of the same, with all rents, profits, etc., therefrom. Under this charter the city had the right to build and regulate wharves, piers, etc., and to make all necessary ordinances therefor.

The Montgomerie charter, together with the Dongon charter, which it fully ratified and confirmed, is usually considered the fundamental source of all titles to real estate on Manhattan Island.

Extension of the 400 ft. under the Laws of 1807 and 1826.—On April 3, 1807, the Commissioners of the Land Office granted to the City of New York all rights of the State to land under water on the East River shore of the Hudson River for a width of 400 ft., extending outshore from low water mark from Bestaver's Killitie northerly for a distance of four miles, that is, to about Seventy-fifth Street; and on the westerly shore of the East River for a width of 400 ft., extending from low water mark from the north side of Corlears Hook, or between Stanton and Houston Streets, two miles north, or to about Fortieth Street.

In 1821, the Legislature granted to the corporation the land under water at the Battery, extending outshore to an irregular line considerably beyond the present sea wall, between the southerly side of Battery Place and the westerly side of Whitehall Street.

On February 25, 1826, the Legislature extended this 400-ft. strip on the North River northerly to Spuyten Duyvil Creek, and on the East River north and along the Harlem River to Spuyten Duyvil Creek, thus completing to the city the chain of title to lands under water around Manhattan Island, extending from high water mark

to 400 ft. beyond low water mark, with all pre-emptive rights preserved, excepting, as just stated, where at the Battery no 400-ft. line prevailed, but in its stead an irregular line.

It may be interesting to know that the 400 ft. under the Montgomerie Charter were required under the terms of the charter to be measured on lines at right angles with a specified base line, extending in a straight line from Bestaver's Kills to Battery Place on the North River, and on the East River at right angles with two specified base lines, one extending from Whitehall Street to Corlears Street, where it deflected to the left or westward through an angle of about 67°, and then runs northerly to a point between Stanton and Houston Streets. These are arbitrary lines, but are fixed by the charter.

Later Grants to the City.—By Chapter 182 of the Laws of 1837, Thirteenth Avenue was made the exterior street on the North River, between the southerly line of Hammond Street, or West Eleventh Street, and the northerly line of West One Hundred and Thirty-fifth Street. By this act all streets south of One Hundred and Thirty-fifth Street were extended to Thirteenth Avenue, and the right in fee to all lands under water along the North River shore of Manhattan Island from Hammond or West Eleventh to One Hundred and Thirty-fifth Street, extending from the exterior line granted under the Law of 1826 to the westerly side of Thirteenth Avenue was given to the City of New York.

Chapter 285 of the Laws of 1862 authorized the Common Council to lay out a permanent exterior street along the shore of the Harlem River from the Hudson to the East River, the State relinquishing to the city all rights to any lands under water from low water to and including the said exterior street. Accordingly, a 70-ft. street was established by the Common Council, October 29, 1859, extending from East Eighty-ninth Street northerly along the East and Harlem Rivers to the Hudson River, with its exterior line coinciding with the bulkhead and pierhead line established by the Harbor Commissioners of 1857, the city thereby coming into possession of additional tracts of land under water along the Manhattan shore of the Harlem River.

At the time of the organization of the Department of Docks, thirty-four years ago, the Legislature, under Chapter 137 of the

Laws of 1870, as amended by Chapter 574 of the Laws of 1871, authorized the Commissioners of the Land Office to convey to the City of New York all property, right, title and interest of the people of the State of New York in and to the land under water required by the Board of Docks for the construction of wharves, docks, piers, bulkheads, basins and slips under the aforesaid act, whenever said Commissioners might be required by said Board to make such conveyance. Accordingly, the Commissioners of the Land Office granted to the City of New York all the hitherto ungranted land under water extending out to a definitely described line encircling the entire island of Manhattan. This grant was signed by Governor Hoffman, and passed the office of the Secretary of State, September 28, 1871. The line therein described now forms the exterior boundary of land under water belonging to the City of New York around Manhattan Island, and is in most places several hundred feet outshore of the 400-ft. line granted by the Montgomerie Charter and subsequent acts.

The foregoing cases, from the Dongon Charter down to the last mentioned conveyance from the Commissioners of the Land Office, embody the principal instances of transfer of title to land under water around Manhattan Island to the City of New York. From time to time during the last century exterior streets, such as West Street, South Street, Tompkins Street, etc., have been established by acts of the Legislature or by city ordinances, subsequently confirmed by acts of the Legislature.

Grant in the Twenty-third and Twenty-fourth Wards.—That portion of what is now the Borough of the Bronx, west of the Bronx River, and formerly known as the Twenty-third and Twenty-fourth Wards, became and was constituted by act of the Legislature, known as Chapter 613 of the Laws of 1873, a part of the City and County of New York, and under Chapter 410 of the Laws of 1882 the Commissioners of the Land Office were authorized to convey as before on the requisition of the Department of Docks, all property, right, title and interest of the people of the State in and to land under water as described in the requisition. Accordingly, a grant was issued by the Commissioners of the Land Office, extending from the mouth of the Bronx River, around through the Bronx Kills, along the Harlem River, through Spuyten Duyvil Creek to the Hudson

River, and thence along the Hudson River to the prolongation of the city line, bounded by a definitely described line, which was signed by Governor Hill and passed the office of the Secretary of State April 5, 1888. This grant at the present time constitutes the exterior limit of land under water owned by the City of New York in the Borough of the Bronx.

Grants in the Borough of Brooklyn.—In what was formerly the City of Brooklyn no little confusion has been caused by frequent acts of the Legislature covering the period between 1830 and 1898, authorizing different individuals to erect wharves, build bulkheads, fill in land under water, etc., within certain established lines that seem to have been changed by extension or modification from time to time by subsequent legislative enactments. Outside of the grant along the Brooklyn shore conveyed to the City of New York by the Cornbury Charter, the city owns no land under water by direct conveyance from the State.

Grants in the Boroughs of Queens and Richmond.—In those portions of the water front of the present City of New York, comprising the Boroughs of Queens and Richmond, the city has not as yet been favored by the State with any special conveyance of land under water, excepting that under an ancient grant to the inhabitants of the town of Jamaica, all the common and marsh lands in, under and about Jamaica Bay were granted to the former town of Jamaica, which naturally passed into the possession of the City of New York at the time of consolidation in 1898, the extent of which has not yet been definitely determined, but is believed to be in the neighborhood of 13 000 acres; and excepting that in the Borough of Richmond, on the application of the Commissioner of Docks in 1903, narrow strips of land under water covering the width of the extended streets were granted by the Commissioners of the Land Office to the city on April 28, 1904, at Tyson Street, and at Bard Avenue, Livingston, and at Summerfield Avenue, Mariners' Harbor, all on the Kill von Kull or Newark Bay.

From the very earliest times, therefore, the wisdom of increasing the city's dominion and control of the water front was fully recognized. This dominion over the lands under water acquired by any of the charters was absolute and complete, and the city could fill in

such lands or build piers and bulkheads and regulate and control wharfage accruing therefrom. And whatever rights the city possessed in this respect it could *convey* or transfer to individuals, or authorize individuals to exercise.

But the city for a long period was in no financial condition to undertake any systematic improvement of its water front. And most of the wharves, piers and slips built during that period of its history, comprising the century preceding the creation of the Department of Docks, were built by private parties or individual owners who were, from time to time, able to obtain from the corporation water grants fronting upon their upland holdings, to which they were recognized as having a pre-emptive right. These grants, prior to 1844, were nearly all made by the Common Council. Thereafter they were made by the Commissioners of the Sinking Fund, and all are presumed to be recorded in the Real Estate Bureau of the Department of Finance, the first recorded grant being to Peter DeLancey, between Broad and Moore Streets, November 19, 1686.

Grants made by the city of land between high and low water, acquired under the Dongon Charter, were generally uniform in character.

Grants made by the city of land acquired by the Montgomerie Charter generally extended across the entire 400-ft. strip, and provided for the building of a 40-ft. street by the grantees on the easterly and westerly sides of the city, which 40-ft. street was authorized by the Montgomerie Charter, the latter being construed as authorizing these streets to be built beyond the 400-ft. line, but, owing to the sinuosity of the shore lines, these grants necessarily extended to an irregular line, which the Common Council undertook to remedy in 1796 by establishing South and West Streets 70 ft. wide, at the same time extending the water lots theretofore granted out to the new street.

The established locations of West and South Streets raised a question as to the city's right to fill in or to build piers outside of the 400-ft. strip, so the Legislature, in 1798, in response to a petition from the Common Council, passed "An Act concerning certain streets, wharves, and piers, etc.," authorizing the city to lay out, according to such plan, as it should or might agree upon or determine, such streets or wharves in front of those parts of the city ad-

joining the East and North Rivers, as it might think proper; and authorized the city to lengthen and extend the intersecting streets and wharves in accordance with such plans, at the expense of adjoining owners, or the nearest and opposite owners, and required the owners of lots not immediately adjoining said streets or wharves to fill in and grade the intervening spaces between their holdings and said streets or wharves, upon the fulfillment whereof said owners, by this act, became possessed of said spaces in fee simple, it being in effect an extension of grant.

This act also provided that the city might, at its discretion, direct piers to be built in front of said streets or wharves at the expense of owners of lots lying opposite those places where piers were directed to be built, said owners to receive the wharfage and all other advantages arising therefrom, but in case of neglect or refusal to comply with the order of the Common Council, the act conferred upon the city authority to build such piers itself and to receive all wharfage therefrom.

In December, 1807, the Commissioners of the Land Office, by letters patent, granted to the city all right and title of the people of the State to lands under water along the East and North Rivers required for the construction of slips, basins, wharves and piers, in accordance with the map or plan of the city.

A general policy was, therefore, inaugurated by the city in 1798 which extended down to the time of the creation of the Dock Department, and grantees or their successors in title, having fulfilled the covenants of their grants, held and do now hold all wharfage and benefits arising therefrom forever.

On the East River, extending from Whitehall to Roosevelt Street, there are three tiers of these grants; the original high water mark in this locality closely followed the southerly line or outshore line of Pearl Street. The first tier of grants extended from this line, that is, from the southerly line of Pearl Street to low water mark, along which Water Street was subsequently built. After the city came into possession of the 400-ft. strip outside of low water mark, a second tier of grants was made, extending from Water Street to Front Street, and later still a third tier, extending from Front to South Streets.

As a usual thing, by the time the third tier of grants, before

alluded to, was made, or subsequent to about 1770, a uniform covenant was made in all grants that all land under water at the foot of streets was to be reserved to the city, and that, as part compensation for such grants, the grantee was to build, not only his own improvement, but also a pier at the foot of such streets, or, at any rate, a pier in which the city should hold a half interest. An almost uniform covenant reserved to the city out of the grants all street areas, and, in accordance with the terms of the grants, the grantees were obliged, within six months after a notice from the Common Council, to build such streets, pave them and keep them in repair *forever.* This condition runs with the title, and in many instances property abutting on these streets is liable to-day for all improvement and repairs to the same.

It appears safe to estimate that the city relinquished about 95% of its water front on both rivers below Forty-second Street by this practice. And when, after the Civil War, the rapidly increasing demands of commerce made it necessary to revolutionize this system, the city was confronted with a situation that, in order to carry out urgent improvement, rendered it imperative to purchase back, by agreement or condemnation proceedings, the property which it had formerly disposed of, as already described, which property had by that time greatly enhanced in value, not only by virtue of improvements made by owners and by the increasing demands for wharfage, but by reason of its unearned increments, location, desirability and convenience.

These conditions prevailed to a greater or less extent from the incorporation of the city in 1653, during its colonial career as a province of Great Britain, down to the time when the powers and prerogatives which had belonged either to the Crown or to Parliament became vested in the State of New York by the Declaration of Independence, and the subsequent close of the Revolutionary War. Thereafter, all concessions to the city were obtained from the State, and, as already shown, these concessions from time to time appeared in the form of legislative enactments or charters, or were made by the Commissioners of the Land Office under legislative authority.

Prior to 1870 nearly all of the improved water front was built up under this system. In some cases the city itself built the struc-

tures, retaining the whole of the wharfage, and in others it joined with private owners and retained part. In this way the city acquired an interest in many old piers and bulkheads, which it holds to this day.

Nor was the policy of disposing of the water front in this manner altogether an unwise one, for the grants were not made solely for the benefit of the grantee; they were made for a valuable consideration, and primarily for the benefit of the city in pursuance of the general policy for improving the water front and attracting commerce; and, during a period when the city was hardly in a condition to enter upon any extensive work of this nature, it insured private improvement, which certainly increased the taxable property, thereby adding to the city's revenue a fund for meeting the ever-increasing expenses of municipal government.

Although the city was clothed with all authority necessary for building its own wharves on its own property, it still lacked the right to build on land under water belonging to the State. The first specific legislation by the State in reference to the city's piers was in 1798, as already outlined, followed in 1801 by the grant of a general power to build and maintain wharves; and in 1806 "to cause "piers to be sunk in such places and manner as it should think "eligible between Whitehall and Exchange Slip, and at its own ex- "pense to cause such and so many public basins to be formed and "completed in said city as it might deem necessary for the trade "thereof; and to take to its own use the wharfage arising from the "same."

In 1813, this act was extended to include the entire city. With the exception of the Act of 1826 and the Revised Code of 1830, there was little legislation bearing directly upon this feature until 1849, when a "Street Department" was organized, with supervision over and authority to build and repair wharves and piers.

An amendment to this act in 1853 provided for the leasing of ferries, docks, piers and slips at public auction to the highest bidder with adequate security, ferry leases being revocable by the Common Council for mismanagement or neglect.

A further amendment in 1857 established a Bureau for the Street Department with a *Superintendent of Wharves* at its head. The provisions of the Act of 1853, requiring all ferries, docks, piers

and slips to be leased at public auction, was re-enacted, all leases to be signed by the Clerk of the Board of Aldermen.

This brings us to the next important act of the Legislature.

Origin and Creation of the Department of Docks.

Naturally, that portion of the water front which had been developed (principally below Thirty-fourth Street) was improved in a most heterogeneous manner by the erection of piers and bulkheads, either by the city or by private owners, under permits issued by the Common Council. In many instances, the city acquired a half interest in some of these old piers in consideration for privileges extended to private owners. This interest used to be regarded as a specific half, that is, either the northerly, or southerly, or easterly, or westerly half, as the case might be; but the Corporation Counsel has in recent years held that this interest is an indefinite half interest, and such property is now condemned accordingly.

The wharf structures thus erected were mostly instances of the caprice of their owners, built without system or uniformity, with little regard for commercial needs, and with a surprising lack of intelligent design. The piers had been built with indifferent lengths, crowded together with varying slip widths, and so narrow as to be devoid of sufficient stability to retain their alignment, and to render it impracticable in many instances to load and unload vessels from opposite sides of the same pier. The accommodations afforded became utterly inadequate, and resulted in driving to New Jersey some of the large steamship companies, which better facilities than those that this city afforded at that time would have attracted to the Manhattan side of the Hudson River. One of these companies, the Cunard, returned to this side of the North River not long after the organization of the Department of Docks.

But a description of the New York water front at this time would not be complete without a reference to a most vicious and ill-advised policy of discharging sewers at the bulkheads. The folly attending this practice, augmented by the prevailing construction of piers where the crib-block and bridge plan was mostly used, resulted in a fearful condition of the slips. There was no systematic conduct in the operation of dredging, and slips were allowed to fill up until the actual necessities of the case compelled the owners to dredge. In

reference to the structures themselves, the Department has never made any systematic effort to determine their history, owing to confusion and incompleteness in the old records. But the large hewn timbers used in their construction, the advanced stage of decay in many of the structures, and the fact that they had outlived their usefulness are all evidences of age rather than of use, and it does not seem rash to estimate that some of these structures had been built fifty years or more. The condition of the water front, the lack of any well-defined system or policy for improving it, and the rapidly increasing commercial demands on the Port of New York were the chief contributing factors which led the Legislature in 1870, following the upheaval occasioned by the exposure of the so-called Tweed Ring, to enact a new charter, Chapter 137, reorganizing the government of New York City. Plate LI, Fig. 1, shows the dilapidation that existed at the old Jackson Street Ferry at the time of the organization of the Department.

Section 99 created the Department of Docks, with a head consisting of a Board of five Commissioners, to be appointed by the Mayor, with powers, duties and compensation to be defined by the Commissioners of the Sinking Fund. This Board was authorized to expend annually in the repairs and reconstruction of wharves, piers and slips not more than $350 000.

The Mayor, A. Oakie Hall, on April 9th, accordingly appointed as a Board of Commissioners, Wilson G. Hunt, William Wood, John T. Agnew, Hugh Smith and Richard M. Henry for a term of five years.

On May 2d, these gentlemen organized the Department of Docks, and with few changes conducted the affairs of the Department until their successors, Jacob Westervelt, William Gardner and William Budd, were appointed by the Mayor under Chapter 335 of the Laws of 1873, reducing the Board from five to three Commissioners.

The Department, thus organized, was given exclusive charge and control, subject to the Commissioners of the Sinking Fund, in certain particulars, of all wharf property, including all wharves, piers, bulkheads, structures thereon and waters adjacent thereto, belonging to the corporation of the City of New York; all wharf property of every description, with all appurtenances which the city might acquire; exclusive charge and control of repairing, building, main-

taining, altering, strengthening, leasing and protecting said property; all cleaning, dredging and deepening necessary in and about the same; exclusive government and regulation of all wharf property of whatever nature not owned by said corporation; authority to acquire property by purchase or by condemnation proceedings; authority to lease all property, excepting that in specially appropriated districts, at public auction, for terms not exceeding ten years, with privileges of renewal for ten-year terms at increased rental.

The Comptroller was to issue bonds when directed by the Commissioners of the Sinking Fund, for raising money to carry on the provisions of this act, which money was to be paid out by the Comptroller from time to time on requisition of the Board of Docks, the limit of bond issue being fixed not to exceed $3 000 000 in any one year.

The sale of ferry franchises and leasing of ferries were vested with the Commissioners of the Sinking Fund.

Thus, the Department was clothed with extraordinary powers and, unlike any other municipal department, was entirely independent of the Board of Estimate and Apportionment.

Up to January, 1902, the Department was governed by a Board of three Commissioners, changing in personnel from time to time as the successive municipal administrations have willed according to law.

On January 1, 1898, the name of the Department was changed under the new charter to the Department of Docks and Ferries, with more extended powers than formerly.

On January 1, 1902, the Department entered upon an entirely new era of government by a single Commissioner appointed by the Mayor, aided by a Deputy Commissioner, in accordance with the Amended Charter, Chapter 466, of the Laws of 1901, possessed with more extended powers than his predecessors.

Jurisdiction, Powers and Duties.—The jurisdiction of the Department at the time of its organization extended over the waterfront of the entire city, which by the Revised Statutes of 1830 was made to comprise all that part of the State designated under the Acts of 1683 and 1781 as the County of New York, and embraced Manhattan Island, Governor's or Mannings Island, the Oyster Islands and Ward's, Randall's and Blackwell's Islands, or about 38 miles of waterfront.

At various times the city has relinquished by cession to the United States Government, Bedloe's, Ellis and Governor's Islands and the Barge Office reservation. The old City of Brooklyn in like manner ceded the Navy Yard portion of the Wallabout.

Three important acquisitions have been made since 1870; first, when under the Annexation Act of 1874 about 22 miles of waterfront along the Hudson, Harlem, East and Bronx Rivers from the city line at Mt. St. Vincent around to and including the Bronx River were added; second, when under the Annexation Act of 1895 the territory east of the Bronx River was added, extending along the East River and Long Island Sound to Hunter Island, making about 40 miles additional; and, finally, when under the Greater New York Charter in 1897 the jurisdiction of the Department was made to cover the entire waterfront of the city as defined by the Act, or about 445 miles, the distance from New York to Buffalo.

Questions relating to the inshore limitations of the Department's jurisdiction frequently arise and occasion a little perfunctory controversy between the Dock Department and other Departments. Wherever a new plan is established the Department's jurisdiction is definitely bounded by the interior line of the proposed marginal street; otherwise, it is indeterminate and must rest upon the decision of the Commissioner of Docks based usually upon a consideration of the probable territory required for possible treatment under a plan for future improvement. It is but fair to the other co-ordinate branches of the city government to record that they uniformly and courteously acquiesce in his ruling.

In all matters pertaining to the government and control of waterfront property, the purchasing or leasing of property, the adoption of new plan maps for waterfront improvement, and the actual operations of construction work of the Department, the Commissioner of Docks takes the initiative.

The official acts of the Commissioner are, however, subject to a very much broader field of approval by the Commissioners of the Sinking Fund than appeared before the amended charter.

The Commissioner is authorized, subject to the approval of the Commissioners of the Sinking Fund:

To establish bulkhead and pierhead lines.

To adopt and execute general plans or make changes in previously adopted plans for waterfront improvement.

To exercise exclusive charge and control over the ferry property belonging to the city.

To establish new ferries and lease the franchises and ferry property.

To widen, open, construct, abandon or close exterior streets or avenues, and to maintain widened portions of such streets.

To regulate the use of marginal streets in the transfer of goods or merchandise upon, over or under all such streets, the single statutory exception being the Harlem River driveway.

To take title to wharf property in the name of the city after agreement with owners as to purchase price, and in case of non-agreement.

To request the Board of Estimate and Apportionment to direct the Corporation Counsel to take legal proceedings to acquire by condemnation.

To lease at public auction any wharf property belonging to the city for a term not exceeding ten years and to covenant for renewal at advanced rents for terms of ten years, not to exceed in the aggregate 50 years.

To lease city waterfront property without public auction, the terms and covenants to be approved by the Commissioners of the Sinking Fund.

The Commissioner is also authorized, without any approval of the Commissioners of the Sinking Fund:

To grant permits terminable at the will of the Commissioner for the occupancy of wharf property for a period not exceeding one year.

To designate a suitable location for the sole use of the oyster business, subject to revocation at any time.

To designate accessible, convenient and safe berths for mooring the free floating baths upon requisition of Borough Presidents.

To designate and set apart suitable and sufficient wharves, piers, bulkheads and berths for the use of the Department of Street Cleaning and the Department of Health.

To set apart so much of the waterfront owned by the city as shall be deemed necessary for the exclusive use of the Fire Department.

To make contracts for construction work, dredging, materials, supplies, etc., not including contracts for repairs under the sum of $1 000.

To direct private owners to dredge or deepen the slips alongside of or adjoining their wharves, piers or bulkheads, and in default to cause the same to be done, the expense for which shall become a lien against the property.

To set apart certain piers as he may deem necessary for the use of the inhabitants for free, healthful recreation, and for the convenience of dealers in country produce and other merchandise brought to the city for sale.

To build sheds for the protection of property on piers or bulkheads belonging to the city, and to lease the same.

To grant permits to lessees or private owners for the erection of such structures, subject solely to the regulations of the Commissioner of Docks.

To make rules and regulations and give such directions as will secure despatch in loading and unloading vessels and the prompt removal of the same from the pier as soon as completed, also such as shall be necessary to prevent any unnecessary accumulation of freight or merchandise while any vessel shall be engaged in receiving or discharging cargo; and in case of failure to comply with the directions of the Commissioner in this respect without unreasonable delay, he may employ such labor or assistance as may be necessary to carry out such order or direction, the expense involved being a lien upon the property to be enforced by warrant of attachment.

To set apart and reserve that portion of the East River waterfront from the westerly side of Pier No. 3, to and including the easterly side of Pier No. 8; also that part of the North River waterfront between the northerly side of West Fifty-first street pier and the southerly side of West Fifty-fourth street pier from the 20th of March to the 31st of December in each year for the exclusive use and accommodation of canal boats and barges engaged in the business of transporting property on the Hudson River or coming to tide water from the canals of the State, and for the use of lighters engaged in loading and unloading such boats or barges.

To order the removal of any ship or vessel from any portion of the waterfront which it is not entitled to occupy.

To set apart the waterfront from Gansevoort street to Little West Twelfth street for the use of boats, barges or other vessels engaged in the business of transporting farm and garden produce.

To assign and designate for the Commissioner of Street Cleaning such piers and bulkheads on the East and North Rivers as the Commissioner of Docks may deem proper for the dumping of snow and ice.

To regulate wharfage and dockage rates and to appoint dock masters, who in addition to assigning and regulating stations for vessels shall collect said wharfage charges.

Organization.—The present organization of the Department comprises the administrative head and three bureaus. The administrative functions are presided over directly by the Commissioner, assisted by the Deputy Commissioner and Secretary with a force of thirteen clerks, stenographers and messengers.

The first Bureau or Bureau of Construction and Repairs is presided over by the Engineer-in-Chief with a staff of nineteen Assistant Engineers, two Mechanical Engineers and a Surveyor, with a working force of thirty-two stenographers, clerks and messengers, twenty draughtsmen and seventy-five field assistants. This Bureau has immediate charge of the topographical and hydrographical surveys of the waterfront; the studies for and preparation of so-called "New Plans" for waterfront improvement; the designing, the planning, the specifications for and the supervision over all improvement or contract work of whatever nature, repairs and dredging on city property; examination of plans and applications for permits for improvement, alterations, repairs and dredging, etc., on private and leased property; the supervision of all work under permits on leased and private property; the Department yards; plant, floating property, etc., these operations outside of contract work maintaining a force of fifty-three ship carpenters, three hundred and eighteen dock builders, with stone cutters, masons, enginemen, stokers, riggers, blacksmiths, machinists, pavers, painters, boatmen, etc., to the number of two hundred and twenty, and nine captains or pilots, nine divers, fourteen inspectors, fifty foremen, one hundred and sixteen watchmen and three hundred laborers or a total in this Bureau of twelve hundred and forty men.

The second Bureau or Bureau of Superintendence is in charge

of the Dock Superintendent, assisted by two assistants, twenty-one dock masters, eight foremen of laborers, two hundred laborers (sweepers), fifty-six male and twenty-one female cleaners and thirty-nine male and thirty-two female attendants at the recreation piers. Assisted by the dock masters, who are vested with all the powers and duties of the old-time harbor master, he is the executive officer of the Commissioner in enforcing the rules, regulations and directions of the latter pertaining to or for securing despatch in the loading and unloading of vessels; the prompt removal of vessels from piers as soon as loading is completed; the removal of a vessel from any portion of the waterfront which it is not entitled to occupy; the assigning and regulating of stations and berths for vessels; the collection of wharfage charges; the prevention of the erection of any structure, or even the driving of a pile along the waterfront or within the Department's jurisdiction by lessees or private owners except under a permit issued by the Commissioner; the berthing of baths; the occupancy of certain piers, bulkheads or slips under the assignment and reservation of certain portions of the waterfront for special kinds of commerce; the examination of applications for leases, permanent berths, special occupancy, ferries, etc.; the use of the marginal streets and bulkheads in the transportation of goods and merchandise; the cleaning of unleased wharves, piers, bulkheads and marginal streets as well as the various buildings of the Department; the care and maintenance of the recreation piers, and in general a sort of police supervision over the whole waterfront, the latter being divided into districts, to each one of which a dock master is assigned. There are fifteen in the Boroughs of Manhattan and Richmond, one in the Borough of The Bronx, four in Brooklyn and one in Queens.

The legal *per diem* wharfage charges authorized by the Legislature may be of interest and are as follows:

Regular Wharfage.—2 cents per ton up to 200 tons and ½ cent per ton for any excess over 200 tons. If a vessel occupies an outside berth and is not working cargo or ballast, one-half of this rate.

Floating Grain Elevators and Sailing Lighters.—Half rates.

Floating Structures.—Not otherwise provided for, double rates.

North River Barges, Market Boats and Barges, Sloops, employed upon the rivers and waters of the State, and schooners em-

ployed exclusively upon the rivers and waters of the State, as follows:

Under 50 tons								.50	cents.
50	tons	and	under	100	tons			.62½	"
100	"	"	"	150	"			.75	"
150	"	"	"	200	"			.87½	"
200	"	"	"	250	"			$1.00	"
250	"	"	"	300	"			1.12½	"
300	"	"	"	350	"			1.25	"
350	"	"	"	400	"			1.37½	"
400	"	"	"	450	"			1.50	"
450	"	"	"	500	"			1.62½	"
500	"	"	"	550	"			1.75	"
550	"	"	"	600	"			1.87½	"

For 600 tons and upwards—12½ cents per 50 tons in excess of last rate.

Canal Boats.—50 cents loaded; 30 cents unloaded.

Vessels Freighting Brick.—Upon the Hudson River, same rate.

Clam and Oyster Vessels.—Under 200 tons 1½ cents per ton for an inside berth and 1 cent per ton for an outside berth, but no vessel to pay less than 25 cents per day, nor for less than one day; 24 hours from the time of day or night when a boat reaches a pier or slip constitutes a day for canal boats, brick vessels, clam, oyster and all other vessels; a fraction of a day counts as one day, and vessels remaining any fraction over 24 hours pay for another day.

Top wharfage on merchandise, 5 cents per ton (accrues after the expiration of 24 hours from time of landing).

At city piers, which are shedded, the foregoing rates are doubled except for boats navigating the canals of the State.

No "credit wharfage" allowed without a written application to the Commissioner, and his written order thereon.

Free lighterage limits established by the railroads which are members of the Trunk Line Association in New York for water delivery of their ordinary freight without extra charge (but not less than car-load lots except for export) are as follows: (See circulars and maps issued by general freight agent of railroads, showing piers for receipt of freight, etc.), on the North River, Man-

hattan shore, Dock Districts Nos. 2, 4, 6, 8, 10, 12 and in No. 14 to West 135th street.

On the East and Harlem Rivers and Upper New York Bay, Manhattan shore, Dock Districts, parts of No. 1, the whole of Nos. 3, 5, 7, 9, 11, 13 and in No. 15 to Jerome Avenue Bridge.

Queens and Brooklyn shores, Dock District, part of 17 and 20 and the whole of Nos. 18 and 19, to wit: From Pot Cove, Astoria, to second bridge, Newtown Creek and points in Wallabout Canal, west of Washington avenue bridge and to Hamilton Avenue Bridge, Gowanus Canal, and to Sixty-sixth street, South Brooklyn.

Richmond shore, Dock District, part of No. 1, namely, points on the north and east shores of Staten Island between Port Richmond and Clifton, both inclusive.

The third Bureau, or Bureau of Accounts is in charge of the Chief Clerk or Auditor, assisted by nine clerks, messengers and collectors. He has charge of the collection of revenues, including rentals, general wharfage, etc.; the examination of applications for credit wharfage, leases, rentals, etc.; apportionment of expenses; payrolls and all accounts of the Department.

General Plan of Waterfront Improvement.

Shortly after the organization of the Department in 1870, the Board under the guidance of Gen. McClellan, its Engineer-in-Chief, undertook to devise a general scheme of improvement for Manhattan Island, south of Fifty-ninth street. To further this end an invitation was extended by advertising, to all persons interested in inaugurating a proper system of wharves and piers, to be present at stated meetings and give their views in person or in writing. Five special meetings were held and seventy different plans were received, many of them containing excellent ideas, which though not novel, were valuable in lending weight to the conclusions subsequently reached by the Commissioners.

In adopting a general plan of wharfage facilities for a port like that of New York three governing principles are to be observed. First, convenience of approach, with adequate depth of water at the dock. Second, the wharf structure must present a minimum obstruction to the free flow of the tide consistent with economy in construction both in time and materials. Third, the arrangement

of wharves must be such as to afford a maximum of accommodation for a given length of waterfront, controlled, of course, by the character of commerce for a particular locality. These principles are fundamental, and the more closely they are followed the more nearly will the practical result approach theoretical simplicity.

There is probably no port in the world where the natural conditions for the execution of such a scheme excel those of the City of New York. Thoroughly well sheltered as a whole, the hydrography and topography of its shores and the range of its tides seem to invite but one rational treatment in the preparation of a general plan. With a tidal range varying from 18 to 33 feet, as at Liverpool, the only system of improvement applicable is the adoption of wet docks or tidal basins. This is the rationale of the magnificent Liverpool docks, and notwithstanding their efficiency in this respect the period for the entrance and departure of vessels is limited to about three hours each tide. This fact, taken with the great cost of such construction and the expense incurred in maintaining an adequate depth in a rapidly silting-up tidal basin only emphasizes the extraordinary natural advantages which enable us in the Port of New York to accomplish so much more at a greatly reduced outlay.

The early adoption of a proper system is vital, for upon its adequacy may depend the whole commercial future of the port. At best, the cost of carrying out any system of waterfront improvement for wharfage purposes is necessarily great, and errors in judgment at this stage, not only increase the cost enormously, but result in serious delays and interference with established lines of traffic. New York may congratulate itself upon having enjoyed the advantage of wise counsel in the direction of the first steps taken in this important work, namely the drafting of a general plan; for after 35 years of practice on these lines we find that the only serious attempt at deviation is that of extension. Briefly stated, the *system* which has worked so successfully here consists in: First, establishing a bulkhead as a limitation for solid filling, and the exterior boundary of a marginal wharf or street. Second, in establishing a pierhead line to limit the outshore position of any structure whatsoever. Third, a system of piers with adequate slips between, extending from the bulkhead to the pierhead line under which the tide may ebb and flow, and alongside of which vessels may safely

FIG. 1.—CONGESTION OF TRAFFIC AT UNIMPROVED PORTION OF WEST STREET.

FIG. 2.—IMPROVED MARGINAL STREET NORTH OF CORTLANDT STREET.

wharf at any stage of the tide, converting a given length of bulkhead or shore line into many times its length of revenue-producing wharfage.

The tangible success of any system must be measured by the net result of a comparison between the cost of construction and maintenance, on the one hand, and the value of maritime commerce or business, which by virtue of its own inherent merits and desirability it can attract and divert to it, on the other hand, this volume of business being the controlling factor in the general prosperity of the entire community. New York's commercial standing and position most effectually and satisfactorily dispose of any question as to the success or failure in this particular of the Department to which this work has been entrusted. But through a wise application of the essential principles enumerated above, the Dock Department has accomplished more than this. It can be shown that New York City's docks are a revenue-producing institution; that the Department has been self-sustaining, and that the revenue is in excess of the expenditures for which not one cent of tribute from public taxation is required.

In developing this system of improvement, a complete topographical and hydrographical survey are the first requisites.

The Bulkhead Line.—The bulkhead line must be located—

First.—After careful consideration for present and future transportation facilities by land to and from the wharves, bearing in mind that under the statute a marginal street, that is, the street of which the physical bulkhead is the outshore boundary, is not a *street* but a *wharf* from which freight and merchandise must be removed by the most direct route to points of delivery or centers of transportation or distribution. The notion of longitudinal traffic or transportation by trucks along the bulkhead must be eliminated from any efficient scheme. Plate XXII, Fig. 1, shows the daily congestion which may be witnessed along the lower end of West Street, where no improvements have yet been made. Get the trucks out of the way by the most direct route to their destination. Plate XXII, Fig. 2, shows the completed portion of the marginal street, extending northerly from Cortlandt Street. The telegraph poles, shown in the photograph, no longer exist. On the other hand, the marginal street should accommodate a system of railroad communication with all piers in a rapidly growing or business section.

Second.—The bulkhead line must be so located as to secure and maintain a proper depth of water, and yet keep the cost of construction of the retaining structure or sea wall within reasonable limits, for where final improvement is made this structure should be permanent.

Third.—If wharfage room is the desideratum, it must not be located so far outshore as to dwarf or render impracticable a system of pier structures.

The Pierhead Line.—The principal features of control in establishing the pierhead line are the contraction of the stream, the maximum length of vessels likely to require accommodation in any given locality, the necessary wharfage room and sufficient depth of water. The Federal Government has, since 1888, established bulkhead and pierhead lines under authority of an Act of Congress, which lines are *limiting* lines, beyond which the municipality is forbidden to establish its lines. It rarely occurs that the Department of Docks ever has occasion to encroach beyond the government's established bulkhead lines, and in the few instances that have happened, the Department has had no difficulty in procuring the necessary modification in the government lines. In the case of the pierhead lines, however, the Department has frequently been the petitioner for an extension of the line further out-stream; for pier lengths are governed by the relative position of bulkhead and pierhead lines. As an illustration of the importance of this feature, the largest steamer of the Cunard Line in the 70's was the *Gallia,* 430 ft. long, with a gross tonnage of 4 800. In 1881 the *Servia* was put in commission, 515 ft. long, with a gross tonnage of 7 400. In 1893, the same company put the *Campania* and *Lucania* in commission 601 ft. long with a gross tonnage of 12 500. At present two Cunarders, the *Coronia* and the *Carmania,* each 675 ft. long, with a gross tonnage of 21 000, and a quadruple screw turbine steamer over 700 ft. long are being built and will require wharfage room on the North River. The only available location for these new Cunard steamers is in what is known as the Chelsea section between Gansevoort Market and West Twenty-third Street, where the Department had adopted a plan for 800-ft. piers. As it is impracticable for a vessel drawing 35 ft. of water to approach within about 50 ft. of the bulkhead wall, these pier lengths would

PLATE XXIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

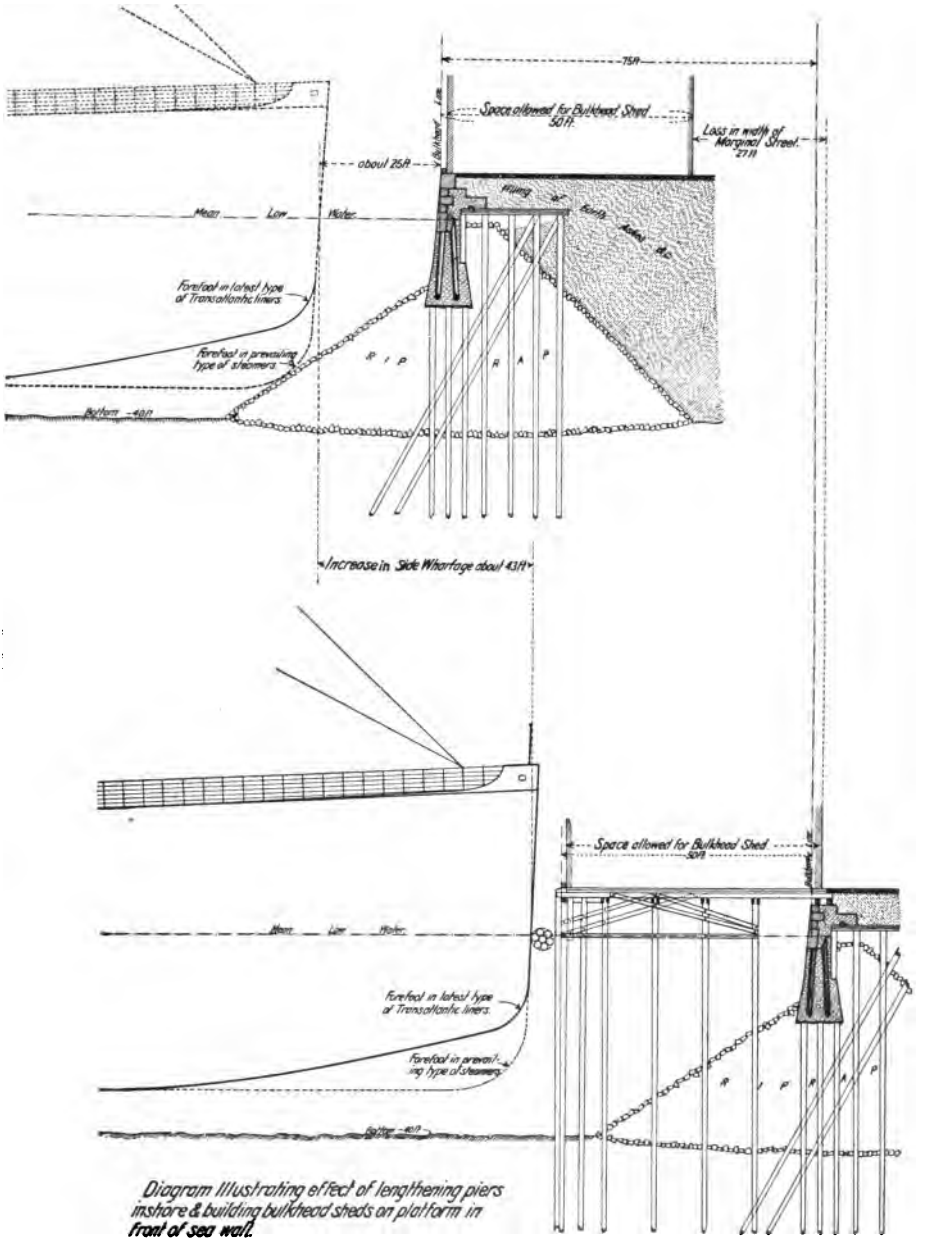

75ft
Space allowed for Bulkhead Shed 50ft.
Loss in width of Marginal Street 27ft
about 25ft
Mean Low Water
Filling
Bottom -40ft
Forefoot in latest type of Transatlantic liners.
Forefoot in prevailing type of steamers.
R I P R A P
Increase in Side Wharfage about 43ft
Space allowed for Bulkhead Shed 50ft.
Mean Low Water
Forefoot in latest type of Transatlantic liners.
Forefoot in prevailing type of steamers.
Bottom -40ft
R I P R A P

Diagram Illustrating effect of lengthening piers inshore & building bulkhead sheds on platform in front of sea wall.

obviously be too short; for a vessel projecting beyond the pierhead is in constant danger of serious damage from passing craft, and is liable for any damage to passing craft occasioned by its exposed position. The imperative necessity for longer piers led the Department, through its Commissioner, to petition the War Department for an extension of the pierhead line, first, 200 feet outshore; but that being denied, a more moderate request of 100 feet was made. After considerable discussion the Harbor Line Board reported against this proposition. So, here we were, the principal commercial port of the Western Continent, practically denied the privilege of providing adequate wharfage in a practicable locality for what will be the largest vessels afloat. Something had to be done to restrain this company from looking elsewhere for accommodation; and the Department did the only thing possible under the circumstances. It changed the bulkhead line, throwing it 75 ft. further inshore, insuring a full mooring pier length of 825 ft. at a sacrifice of 75 ft. in the width of the marginal street.

The advantage of this arrangement is more clearly shown by an inspection of the diagram, Plate XXIII, and the map, Plate XXIV. A vessel can approach no closer to the wall than the riprap will permit. This is ordinarily about 25 ft.; and a bulkhead shed must occupy about 50 ft. in width of the bulkhead, reducing the 250-ft. marginal street practically to a width of 200 ft. Alongside of an 800-ft. pier the stern of the *Baltic,* of the White Star Line, with an over-all length of 726 ft., would lie 49 ft. inside of the outer end of the pier. On the other hand, throwing the bulkhead wall 75 ft. inshore and building a platform for the bulkhead shed in front of the wall, the stem of a vessel can be brought practically close up to the platform, thereby utilizing almost the entire wharfage length of the pier without obstruction; bringing the stern of the same vessel 94 ft. inshore of the outer end of the pier, and affording within 27 ft. the same width of unobstructed marginal street as before. The proximity of approach to the bulkhead wall for steamships, of course, depends upon the shape and depth of the stem at the forefoot. The prevailing type of forefoot in steamers is as shown by the dotted lines in the diagram, the full line representing the shape adopted in the more recent liners.

Time prevents a discussion in this paper of the merits of the

controversy between the Harbor Line Board and the Dock Department; but it is safe to say, that the position taken by the latter is unaltered; for the proposed contraction would not materially affect the tidal prism, and the commercial interest of the only sea port of the Empire State *are not* merely local but extend in effect across the entire continent.

Piers.—In adopting a system of piers, the principal factors of control are, location for special kinds of commerce, adequate but not superabundant width of pier or slip, accessibility, depth of water and pier length, which is limited by the pierhead line. In the actual building of a pier, it is always possible without any special proceeding to make such modifications as to length and width *within* established lines as are justified by immediate requirements. But a very important result in a well-planned system of piers is the conversion of a given length of bulkhead or shore line into several times its length of revenue-producing wharfage. A single instance will serve to illustrate. Take the Chelsea Section, Plate XXIV, for illustration. The bulkhead distance from Bloomfield street to West Twenty-second street, before the present improvement was inaugurated, was 3 100 ft. The completion of this work will result in eight piers, 800 or more ft. long, with 250-ft. slips, making a total wharfage room of 16 550 ft. against 3 100 ft. of waterfront.

The application of any hard and fast rule in the adoption of a general plan is in the very nature of things impracticable; for there are localities, especially in the boroughs outside of Manhattan, where piers will be out of the question, and where no other than bulkhead wharfage can be obtained, or at best a system of basins or slips extending inshore from the bulkhead line—a very efficient system, nevertheless, for small craft.

The principles of design and construction of piers and bulkheads will be taken up in a subsequent section of the paper.

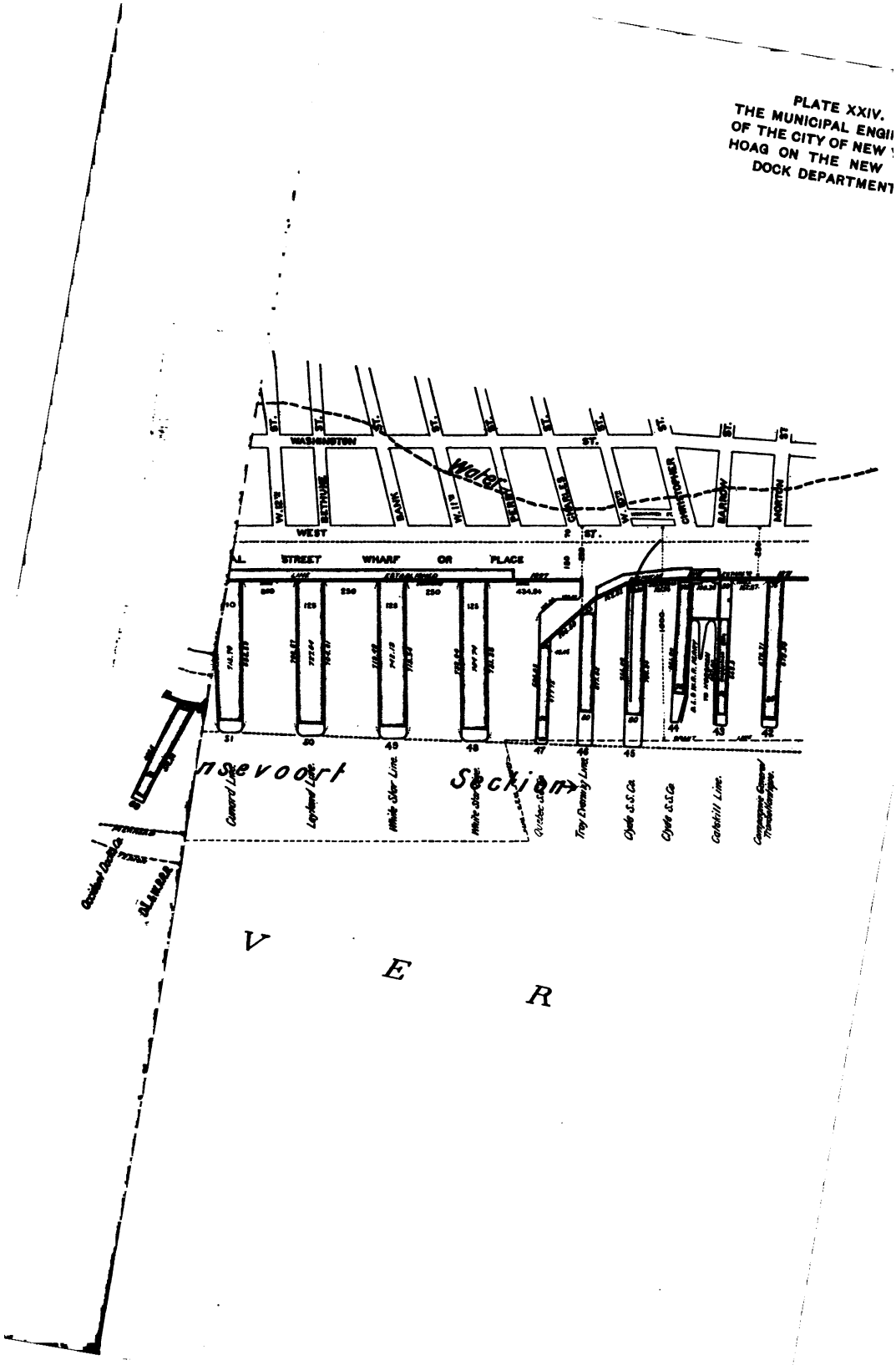
The Department has from time to time established new plans, with the approval of the Commissioners of the Sinking Fund, as follows:

In Manhattan.—On the North River:

From the Battery to Seventy-second street.

Two blocks north and south of Eighty-sixth and Ninety-sixth streets, respectively.

PLATE XXIV.
THE MUNICIPAL ENGI
OF THE CITY OF NEW
HOAG ON THE NEW
DOCK DEPARTMENT



From 129th to 135th street.

On the East and Harlem Rivers:

From the Battery to Forty-second street.

From Forty-ninth to Fifty-third.

From Fifty-ninth to Eighty-first.

From Eighty-ninth to 135th.

At Sherman's Creek.

In the Bronx.—The work on the preparation of new plans has progressed no further than studies for improvement at Fordham Heights, Morris Dock, Bronx River, Westchester Creek and East Chester Creek.

In Brooklyn.—A plan for improving the waterfront at Hamilton avenue was prepared by the Department, but failed to receive the approval of the Commissioners of the Sinking Fund. Beyond this, nothing has been done in this line, excepting that the old City of Brooklyn, before consolidation, established a plan for improving the Wallabout Basin.

In Queens.—Studies for improvement at Hallett's Cove have been carried to an advanced stage.

In Richmond.—New plans have been regularly adopted for ferry improvements at St. George, Stapleton and Port Richmond.

Acquisition of Property.

When the Department of Docks came into existence its most valuable asset was the remaining waterfront property which had not theretofore been conveyed by the city authorities to individual owners in the form of grants from the area of land under water to which the city had come into possession under the Dongon and Montgomerie charters and subsequent acts; and while prior to that time it had not been a particularly difficult matter to obtain a water grant, the attitude of the city as represented by the Department of Docks was now reversed, and it inaugurated the policy of regaining ownership of the waterfront as rapidly as required by the demands for wharfage room. No expenditure of public money could or can be made upon private property for public improvement, and the operations of the Department in the matter of improving the waterfront were then, as now, limited by the waterfront property available for such improvement.

In the actual work of improvement, the Department has at all times been able to at least keep pace with the acquisition of property. Instances have occurred when serious obstruction to, or an almost total cessation of, new construction has been occasioned by injunction suits and delays in condemnation proceedings, due to misunderstanding or misinterpretation of the rights of private owners. For the principles governing the rights of ownership in waterfront property are many and various; but those most generally applicable have been defined by the Court of Appeals in three important cases against the Mayor and others, viz., the Langdon, the Williams and the Kingsland cases. For instance, in the case of Williams vs. the Mayor, Judge Finch, in delivering the opinion of the Court of Appeals, maintained that under the Acts of 1801 and 1813, the State authorized the city to lay out and build wharves and slips in said city whenever and wherever it should deem it expedient; that this amounted to a grant of so much of the State land under water as those wharves would occupy; that this right was tantamount to ownership and inconsistent with the title remaining in the State.

Again, in the Langdon case, Judge Earle, of the same court, declared that when the State granted to the city wharf rights which might cover the State's land under water, it granted two things: property in the land covered by and occupied by the wharf, and an easement for the approach of vessels in front.

And again, that the assumption upon which the laws of 1857 rested, establishing the exterior line of the Harbor Commission, involved a recognition by the State that the removal of the exterior bulkhead line further into the river carried with it a surrender by the State to the city, or its grantees, of the land under water behind the new bulkheads whenever they should be erected, &c., &c.

These principles and others of special import, applying directly to the relations between State and city, are made equally applicable to corresponding relations between the city and its grantees, and serve as an important guide to the city in matters concerning the occupancy or seizure of wharf property for public improvement, saving the city very considerable expense and delay by aiding in adopting such steps as will most likely steer the bark of public improvement clear of injunction proceedings. For the wharf property of

citizens may be taken, but the destruction of wharf rights in any manner whatsoever either by demolition, confiscation, condemnation or interference involves the necessity for *compensation* to the owners. The only two methods of procedure authorized by law are by negotiation and agreement to purchase or by condemnation proceedings under the right of eminent domain.

The Commissioner of Docks, therefore, may take title to wharf property in the name of the city after agreement with the owners as to purchase price, if approved by the Commissioners of the Sinking Fund, or in the case of non-agreement, he may direct the Corporation Counsel to take legal proceedings to request the Board of Estimate and Apportionment to acquire. In several important and specified instances, the Amended Charter provides that it is not necessary for the Commissioner to attempt to agree with owners on a purchase price; but if the Commissioners of the Sinking Fund so direct, title vests in the city four months after the filing of the oaths of the Commissioners of Estimate and Assessment in the proceedings with the Clerk of the Supreme Court; this makes it possible in these important cases to prosecute the work of improvement without any serious delay.

Shortly before the organization of the Department the estimated value of city property along the waterfront, including wharves, piers and bulkheads, was, for the North River, $1 428 000, and, for the East River, $1 829 000; or a total of $3 257 000, which, with $1 200 000, the estimated value of ferry property, makes a total of $4 457 000. These figures cannot be compared with what follows, as they include, not only the value of bare property rights, but also whatever improvements existed at that time.

Since May 1, 1870, to January 1, 1904, the city had acquired ninety-six different pieces of property, thirty-five of which were acquired by negotiation and agreement, twenty-seven by regular condemnation proceedings and thirty-four by seizure for which the city had to pay judgments rendered in favor of the rightful owners. All of this property is in Manhattan and represents in the aggregate an expenditure of $16 935 614.53. Of this sum only $613 628 had been expended up to 1890, showing for the years 1886 and 1887 an almost total cessation of new improvement. At the present time proceedings are under way for acquiring property in thirty-two specific

cases in Manhattan, two in Brooklyn and nine in Richmond. The average price paid by the city for bulkhead property acquired by agreement has been about $575 and $175 per running foot on the North and East Rivers respectively. Under condemnation proceedings, the price paid has averaged about $600 per running foot on the North and $215 on the East River. Under judgments rendered against the city, the price paid per running foot has averaged about $535. In several instances of the latter kind, the cost of interest and law charges has exceeded the cost of the property. The prices paid for old pier structures and pier rights have varied considerably between $4 and $16.50 per sq. ft. Where large areas have been condemned the price paid, including bulkhead and all riparian rights, has averaged about $11 per sq. ft.

Of the 445 miles of waterfront, the city ownership comprises 17.82 miles of bulkhead rights in Manhattan out of a total of 39.9 miles; 5.83 miles in the Bronx out of a total of 105.6 miles; 1.45 in Brooklyn out of a total of 132.3 miles; .08 in Queens out of 116, and .03 in Richmond out of 51; or a total of 25.21 miles exclusive of park waterfront, which amounts to 22.88 miles, making a grand total of 48.09 miles, or about 10 (ten) per cent.

The Dock Department has no jurisdiction whatever over park waterfront, except by courtesy or permission of the Park Department.

The foregoing estimate does not, however, comprise all of the city waterfront property, for the area of land under water outshore of or adjacent to private upland ownership is disproportionately large in comparison with the latter. But, as has been previously shown, the city must first acquire the bulkhead or riparian rights before it can utilize this property for improvement; at the same time, the owners of the riparian rights cannot occupy a square foot of it for private improvement or for any other purpose without the payment of rent to the city. It must be understood in this connection that the mooring or wharfage of vessels *over* land under water does not constitute occupancy of the latter.

Measured by the productive unit, the 25 miles of the city's bulkhead rights provide 62 miles of available wharfage room, of which 55 miles represent improved waterfront property.

The actual value of this property will be discussed in the section of this paper devoted to expenditures and revenues.

General Description of Waterfront.

The waterfront of New York City varies topographically to include the shores of ocean, bay, river and creek. These shores, generally speaking, are of two classes: the low and shelving, on the one hand, and, on the other, the high and steep. These two features are most likely to control any question of availability for commercial purposes. The prevailing nature in all the boroughs is low, a fact that makes a very large percentage of our waterfront immediately available for improvement, either public or private, the character and development of which will largely depend upon local conditions and needs. About three miles and a half of waterfront along the North River at the upper end of Manhattan Island and all the waterfront of The Bronx, extending from Washington Bridge along the Harlem and Hudson Rivers to the Yonkers city line, are generally high, and intercepted along the river front by the N. Y. Central & Hudson River Railroad. These localities are with few exceptions mostly occupied at the present time by owners of large tracts, who maintain large areas around their residences in a semi-natural condition. Any extensive improvement in these sections must await the actual development of a street system. In the meantime, the only improvements that can be made within reasonable limits of expenditure are such as may be actually demanded for furnishing facilities for conveying coal, building materials and market supplies to those more thickly settled portions of the city in the interior or back of the locality alluded to. But any improvement, however temporary, must be made in connection with a complete scheme for an overgrade crossing at the railroads.

In addition to the Barge Office and the Navy Yard, the United States Government owns a waterfront reservation at Fort Hamilton and another at Fort Wadsworth.

The Park Department controls about 23 miles of waterfront, comprising the following parks, which border upon its shores:

In Manhattan.—Battery Park, extending from Whitehall Street to Battery Place. Riverside Park and its extension, extending from West Seventy-second to West One Hundred and Twenty-ninth Street. Fort Washington Park, at Fort Washington Point, extending north and south from West One Hundred and Seventieth Street. Fort George Park and High Bridge Park, with

Harlem Driveway, along the shore of the Harlem River, from West One Hundred and Fifty-fifth Street to Sherman's Creek. Thomas Jefferson Park, between East One Hundred and Eleventh Street and East One Hundred and Fourteenth Street on the Harlem River. East River Park, extending from East Eighty-fourth to East Eighty-ninth Street. John Jay Park, extending from East Seventy-sixth to East Seventy-eighth Street. Park built by the Dock Department, and turned over to the Department of Parks, between East Seventeenth and East Eighteenth Streets.

In the Bronx.—Washington Bridge Park, comprising the area immediately adjacent to the bridge abutments on the easterly side of the Harlem River. High Bridge Park, comprising the area immediately adjacent to the abutment piers of High Bridge. Park foot of Hunt's Point Road, between Hunt's Point Road and Farragut Street. Pelham Bay Park, extending southerly from the City line, including Hunter's Island, Twin Island, Rodman's Neck, a portion of Eastchester Bay and almost all of the entire easterly shore of Eastchester Creek.

In Brooklyn.—Shore Road or Bay Ridge Parkway, extending along the shore of the Upper Bay and Narrows from Sixty-sixth Street to Fort Hamilton and including Fort Hamilton Park at the foot of Fort Hamilton Avenue. Dyker Beach Park, between Seventh Avenue and Bay Eighth Street. Bensonhurst Park, at Twenty-second Avenue. Concourse Lands, at the foot of Ocean Parkway on the Atlantic Ocean. Canarsie Beach, at the foot of Rockaway Parkway.

In the Boroughs of Queens and Richmond there are no public parks immediately adjacent to the waterfront.

Extent of Waterfront.—The waterfront of New York City has been surveyed, plotted and mapped for all of Manhattan, all of the Bronx and all of Brooklyn as far as the easterly end of Coney Island; Queens, as far as Sandford's Point on the East River, with nearly all of Rockaway, and a few islands in Jamaica Bay; and Richmond from St. George, extending westerly along the north shore to the Arthur Kill bridge and extending easterly and southerly as far around as New Dorp on the south shore. The waterfront developed from these surveys and estimated from published maps of the remainder, shows for

Manhattan	39.9	miles.
Bronx	105.6	"
Brooklyn	132.3	"
Queens	116	"
Richmond	51	"
Total	444.8	"

It is the purpose and endeavor to keep the surveys, furthermore, coincident with public or private improvements on all portions of the waterfront. They are always in progress, and keep up a perpetual record of waterfront progress.

Physical Features.—Of the principal physical character of the waterfront, that is, the nature of the bottom, very little has been ascertained outside of Manhattan. Where permanent improvement like the sea wall is contemplated, the usual practice is to take borings along the bulkhead line and on lines 30 to 50 ft. in front of and in rear of the bulkhead line. If the bottom, thus developed, indicates any uncertain features, the number of borings is multiplied and carried on more extended lines. These borings are ordinarily carried down to rock resistance and furnish fairly reliable information regarding the stratification and material through which they penetrate. For almost every other purpose test piles are driven, as the information thus obtained conveys a knowledge of the penetration to which a pile may be driven, and, therefore, the length of pile required and the consistency of the material at different depths—a very important bit of knowledge in determining the measures to be taken for securing proper stability in the structure to be built.

In this way the North River bottom has been very fully developed from the Battery to Seventy-second Street, the East River from the Battery to Stanton Street, from Seventeenth to Twenty-eighth with less continuous or connected data, from Thirty-seventh to One Hundred and Twenty-fifth Street. Owing to the expensive nature of such investigation and to abundance of other work, it is customary to make them only as required for immediate use. Therefore, similar information elsewhere and in the other boroughs is only coextensive with the work done by the Department in those boroughs.

Starting from Battery Place and proceeding northward along the

bulkhead line, rock is disclosed at an average depth of 40 ft. below mean low water, extending as far north as Dey Street. From this point, the depth increases to about 80 ft. at Warren Street, and continues at about this depth to Morton Street, where the bottom takes another dip gradually to a depth of about 175 ft. below mean low water at West Twenty-third Street. This is the deepest rock developed thus far on the entire water front. From this point the rise is gradual and nearly uniform to about West Fifty-second Street, where it occurs at a depth of 25 ft. below mean low water. From this point northerly to about Fifty-ninth Street, the slope is rather gradual to a depth of about 50 ft. below mean low water. North of Fifty-ninth Street, the information is less continuous, but rock is found at Seventy-ninth Street at a depth of 40 ft., at Ninety-sixth Street at a depth of 45 ft., at One Hundred and Twenty-eighth Street at a depth of 50 ft. and at One Hundred and Thirty-fifth Street at a depth of 90 ft. below mean low water.

About 10 ft. of tenacious mud, sand and gravel immediately overlie the rock as far north as Park Place, covered with about 20 ft. of dock mud. From this point north to Christopher Street, coarse sand and gravel with a mixture of clay overlie the rock with a varying thickness of from 10 to 80 ft. surmounted with a layer of mud, sand and shells, varying in thickness from 5 to 30 ft., the whole topped off with about 30 ft. of dock mud. Along that section of the North River where the rock is at its greatest depth, it is covered with a bed of compact blue clay, sand and gravel, varying from a foot to about 35 ft. in thickness. Over this lies a bed of compact mud, varying from about 3 ft. to about 85 ft. in thickness, and over this is about 60 ft. of dock mud. Between Fortieth and Fifty-ninth Streets a thin layer of tenacious mud surmounted with a bed of dock mud, varying from 20 to 50 ft. in thickness overlies the rock.

From Fifty-ninth Street to One Hundred and Thirty-fifth Street, the bottom seems to be dock mud from 5 to 20 ft. thick, overlying a bed of tenacious mud, sand and clay, averaging about 20 ft. in depth.

The geological formation of the East River bottom has not been as fully developed by examination as on the North River, the continuity occurring in detached localities. Along the lower part of the East River from Whitehall Street to Corlears Hook rock occurs just above Whitehall Street at about 18 ft. below mean low water, sloping

down to a depth of about 152 ft. below mean low water at Burling Slip, gradually rising with more or less irregularity to about —50 in neighborhood of Market Slip, with a deep pocket between Market Slip and Clinton Street at about 100 ft. below mean low water, from which point it rises again gradually to about 30 ft. at Gouverneur Slip. The stratification along this section consists of a bed of mud varying in thickness from 3 to 25 ft., overlying a bed of sand, clay and gravel, in some places only 3 or more ft. thick, and in other places about 115 ft. thick. Where the rock is deepest the bed of sand is thickest.

At Stanton Street we find 5 to 10 ft. of mud overlying a bed of sand, clay and gravel of 30 ft., with rock at about 50 ft. below mean low water.

In the stretch from Seventeenth to Twenty-third Streets about 10 ft. of mud overlies a thick bed of sand, clay and gravel, varying from 55 to 95 ft. in thickness with rock from 80 to 115 ft. below mean low water. From Twenty-third Street the rock rises to about —30 at Twenty-fourth Street, sloping back to about —60, at Twenty-eighth Street, with a prevailing depth of from 60 to 70 ft. as far as Thirty-ninth Street, the overlying material being hard sand and clay varying in thickness between 10 and 40 ft., with an overlying bed of about 10 to 20 ft. of mud.

The next section of any importance extends from Sixty-fourth to Eighty-first Street, where the Department is at present engaged in building the exterior street and bulkhead wall. The rock along this stretch is exposed at mean low water in places and has a maximum depth of about 18 ft. with very little overlying material excepting boulders, the rock being swept clean by the very strong current in this portion of the East River.

From Eighty-ninth to Ninety-sixth Street the rock bottom slopes from about —12 to about —115 ft., covered with about from 10 to 60 ft. of fine sand and clay with an overlying stratum of mud about from 10 to 15 ft. thick. At One Hundredth Street rock occurs at about —70, overlaid with the same material, that is, a bed of plastic red sand, diminishing to about 20 ft. in thickness, and disappearing at One Hundred and Fourth Street where the rock rises to about —30 covered with 10 ft. of yellow to gray sand.

North of this point to One Hundred and Seventh Street the rock

dips to —30 where it begins to rise gradually to One Hundred and Twenty-fifth Street to about —12, covered with about 30 ft. of sand and clay as far north as One Hundred and Tenth Street, from which point the overlying stratum is a thin layer of sand and gravel not much over 5 ft. in thickness with mud, varying gradually from 20 ft. to 1 or 2 ft. At One Hundred and Twenty-fifth Street the rock is bare. North of One Hundred and Twenty-fifth Street, the Department has very little accurate information along the bulkhead line.

Along the North and East River water fronts, rock and hard bottom slope as a general thing more or less rapidly outshore, affording ample depth of water without dredging along the pierhead line, and while the penetration of piles is, as a general thing, sufficient for securely holding the latter, the depth of water is such that in many cases it becomes necessary to increase the bottom holding by means of a riprap embankment in order to overcome the top heaviness of a pier and its superstructure. On many portions of the East River, however, there is so little penetration, that it is often necessary to build an artificial bottom by means of riprap; and it was this condition probably that suggested the early form of pier construction by means of sunken cribs with bridged spans, which prevailed before the improvements begun by the Dock Department.

Tides.—The entire waterfront is on tide water which ebbs and flows with ranges varying from 3.74 to 6.97 ft., or, generally speaking, from 3 ft. 9 in. to 7 ft., according to locality. For all work of the Department the plane of local mean low water is the datum. In 1886 this plane and that of mean high water were established with reference to an initial bench mark at City Hall, from a series of automatic tide gauge observations taken at Pier "A." It is customary to lay out work in the disposal of men and material so as to enable the operations to proceed at all stages of the tide without interruption or delay; but as time progressed low water work became more and more difficult, owing to the infrequency with which mean low water occurred at the established level—a difference of 2 or 3 in. in the relative height of the surface, making a great difference in operations at the low water level. This led to a revision of the records in 1898. Taking the automatic records at Pier "A," covering the period of twenty-two years preceding 1898,

the result obtained was an average of all the records, and tends to show that either the datum plane had risen 3 in., or that the land had sunk 3 in. The plane of mean low water was accordingly raised that amount, and mean high water was dropped 0.14 of a foot, making the range at Pier "A" 4.24 ft. against 4.62 ft. as formerly used. This mean low water compared with the average of all recorded low waters from 1886 to 1903 inclusive, shows the latter to be only half an inch above the new mean low water.

There are at present eighteen stations equipped with a self-registering tide gauge, which record covers a period of seven days, located as follows:

In Manhattan.—North River:
At Pier "A."
At West Twenty-third Street Pier.
At West Fifty-seventh Street Pier.
At West One Hundred and Thirty-first Street Pier.
East River:
Grand Street Pier.
East Twenty-fourth Street Pier.
East Sixty-second Street Pier.
Harlem River:
Third Avenue Bridge.
Government Ship Canal at Broadway Bridge.
In the Bronx.—East One Hundred and Forty-second Street Pier at Port Morris.
At Baychester, Pelham Bay.
In Queens.—Third Avenue Pier at College Point.
Jackson Avenue Bridge, Flushing.
Foot of Broadway, Astoria.
Henry Street Pier, Rockaway Beach.
In Brooklyn.—At Forty-seventh Street, South Brooklyn.
At Newtown Dock, Canarsie.
In Richmond.—At the B. & O. Bridge, Arthur Kill.

These gauges are all set by the Surveyor with reference to the datum at Pier "A," the object being to determine the relation be-

tween the latter datum and local mean low water. About forty stations have been occupied in establishing this relation; but some have been abandoned and others have been established at new locations when the observations at a given station have extended over a period sufficient to show a constant variation or uniformity in the relationship sought.

The recorded observations combined with a system of precise levels, show, of course, local variations from the Department datum.

The plane of local mean low water seems to rise on the North River from zero at the Battery to + 0.45 at Fort Washington. Beyond this point it seems to be affected by the Harlem River tides, for in passing up the river through Spuyten Duyvil and down the Harlem River it falls from + 0.45 at Fort Washington to zero at about High Bridge, and continues to fall as we proceed southward to about —0.14 at East Ninety-sixth Street. From this point it rises to + 0.36, as we continue down the East River through the west channel to about East Fourth Street, whence it falls again to zero at the Batttery. Taking the route from East Ninety-sixth Street up the East River and into the Sound, it continues to fall until at City Island it reaches a depression of —1.26 ft. The same phenomenon appears along the Brooklyn and Queens shores, showing a fall from + 0.35 at the Navy Yard to — 1.1 at Whitestone.

Above the Battery, therefore, the gradient of local mean low waters has a summit at Fort Washington and at about Corlear's Hook with City Island at the foot of the grade.

South of the Battery local mean low water along the Brooklyn and Richmond shores naturally falls all the way to Rockaway Beach, where it reaches — 0.26. For Richmond, the summit is in the vicinity of Mariners Harbor at + 0.09, falling both to the Kill von Kull and so on to the ocean and Arthur Kill to about Rossville, which seems to be at the foot of the grade, with an elevation of — 0.45; the gradient rising again from this point around through Raritan Bay to the ocean.

The elevation of local mean high water, on the other hand, north of the Battery falls from + 4.24 at Pier "A," passing up the North River and into the Harlem Ship Canal to + 4.08 at Two Hundred and Sixteenth Street. Continuing down the Harlem and East Rivers it rises to + 4.60 at about One Hundred and Six-

teenth Street, from which place it falls to + 4.15 at about Thirty-fourth Street, whence it rises again to + 4.24 at the Battery.

Proceeding eastward from Hell Gate along the Bronx shore, the rise is rapid from + 4.51 at about Ninety-sixth Street to + 5.71 at City Island.

Following the Brooklyn and Queens shores from opposite the Battery, the plane of mean high water falls to Greenpoint Ferry and then rises continuously to Whitestone.

Thus, it will be seen, that above the Battery the mean high water gradient has depressions at Two Hundred and Sixteenth Street, H. R., and at East Thirty-fourth Street, along the Manhattan shore and at about Greenpoint Ferry on the Brooklyn Shore, with high levels at East One Hundred and Sixteenth Street, in the open Sound and in the Upper Bay. These peculiarities are occasioned by the complex behavior of the flood and ebb tides in the East and Harlem Rivers caused by the Bronx Kills, Little Hell Gate and the opening of the Harlem Ship Canal.

South of the Battery, particularly in Richmond, the phenomena attending the elevation of mean high water are normal and the reverse of those shown for low water, the highest high water occurring at Rossville in Arthur Kill, and the lowest at Mariners Harbor.

As might be expected the maximum tidal ranges in Greater New York with the exception of the Harlem River occur at the points of depression in the low-water plane, and the minimum ranges at the summits. These vary, as stated before, from 6.97 at City Island to 3.75 at Fort Washington, the range at Pier "A" being 4.24. The Harlem River tides seem to defy all theory. Lack of time and opportunity have prevented the writer from devoting to the foregoing tidal phenomena the analysis for theorizing or for deduction; but the facts are presented herewith in the hope that they may draw out discussion on this very interesting topic.

The maximum recorded high water occurred on November 24, 1901, at Pier "A," when it rose to the elevation of + 8 ft. The minimum recorded low water occurred on February 8, 1895, at Pier 'A" when it fell to —4.1 ft., making the maximum range observed at Pier "A" 12.1 ft. It is this range of tide that governs most of the structures with which the Department has to deal. It

may be interesting to note the mean range of tides in the following Ports:

Portland, Maine	8.8 ft.
Boston, Upper Harbor	9.6 "
New London	2.5 "
Philadelphia	5.3 "
Norfolk	2.7 "
Savannah	6.8 "
New Orleans (Port Eads) at mouth of River	0.1 "
Galveston	0.6 "
San Francisco (City proper)	.4 "

The diagram, Plate XXV, Fig. 1, shows maximum high and minimum low waters for every year from 1886 to 1903, inclusive, as well as the mean of low waters for the same years, referred to the present established mean low water line or Department datum. Eliminating all intermediate variations, the curves shown, approximate closely the loci of the points thus plotted; the vertical ordinates representing height, the horizontal ordinates representing time.

These abnormal tides are caused, as a rule, by an unusual combination of circumstances attending the direction and velocity of winds at the time of Spring tide. An inspection of the curves shows for the period of observation a mean low-water gradient approximating in slope the average gradient of highest tides. While the writer does not dispute the apparently demonstrated proposition that the land is sinking, he is of the opinion that these diagrams tend as much to show the effect of encroachment upon the tidal prism by improvements of all kinds along the waterfront.

About two years ago the Department installed at Pier "A" two electric self-recording machines, one for recording the velocity and the other for recording the direction of the wind, and the records thus obtained afford valuable data in conjunction with the tidal records for studying the combined effect of wind and tide.

Thus, we have at hand ready means of comparison between the wind velocity curve and the tidal curve during the storm that prevailed, September 15, 1904. The tidal curve in the diagram, Fig. 4, was recorded on that date by the tide gauge at College Point; and in juxtaposition the curve indicating the normal rise and fall

PLATE XXV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

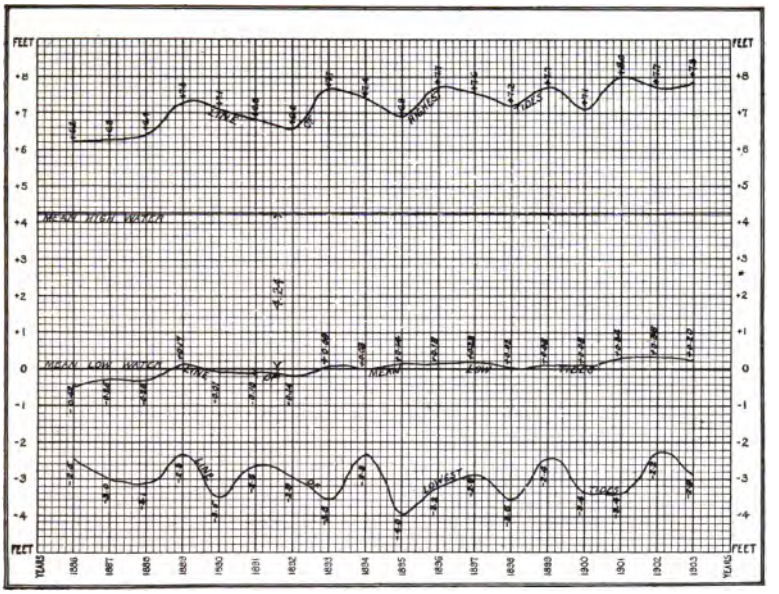


FIG. 1.—DIAGRAM SHOWING CURVES OF EXTREME HIGH AND EXTREME LOW WATERS.

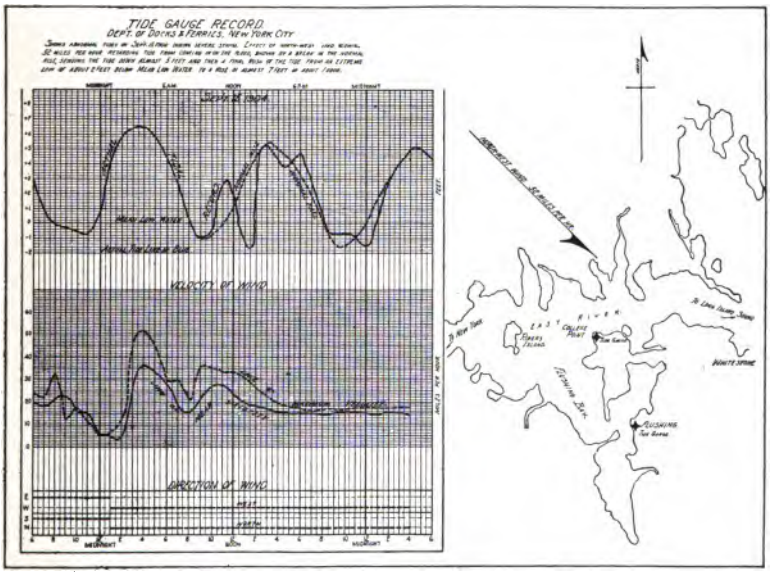


FIG. 2.—DIAGRAMS SHOWING EFFECT ON TIDES OF STORM OF SEPT. 15, 1904.

of the tide at the time of the phenomenon in question is plotted on the same sheet.

At about 1 o'clock in the morning the wind shifted from southeast to northwest, and blew steadily from that direction until past midnight. In three hours the velocity of the wind rose from five miles to fifty-two miles per hour, reaching a maximum velocity at about 4 A. M. about the time of high tide. From this time until about 6 P. M. it continued to blow with decreasing severity, at which time it reached a velocity of about fifteen miles per hour, but the dynamic effect was not felt until the next flood, which under normal conditions should have proceeded continuously from about 9 A. M. to about 3 P. M. But at about the middle of this flood-tide the water was driven back, and then occurred the unusual phenomenon of an extremely low water within 90 minutes of high water about 4½ hours after low tide. At this time the effect of the diminution in velocity of the wind began to be felt and the banked-up mass of water in the Sound, responding to the release from pressure, caused the tide to rise about 7 ft. in about 90 minutes, occasioning considerable alarm amongst many of those who were fortunate enough to observe this in-rush of water from the Sound. High water occurred at about 3 o'clock, after which time with some slight deviation in the tidal curve, due undoubtedly to corresponding deviations in the velocity of the wind, the tide fell and gradually assumed the normal curve by the middle of the next flood tide. This instance is cited to illustrate the great advantage of having simultaneous records for velocity and direction of the wind and the behavior of the tides.

Currents.—The present best available information regarding the tidal currents in the Port of New York is obtained from the United States Coast Survey, which is authority for the figures given later on. Up to the present time the currents in the North and East Rivers have claimed the principal attention in carrying on the Department work. A wide difference exists between the North and East Rivers in this respect.

The rate per hour for flood tide on the North River varies from 1.7 to 0.7 miles, the maximum being 1.7 at Cortlandt Street. The ebb varies but little and is about 2.1 miles per hour. On the East River the flood varies from 2.2 to 5.2 miles per hour, the maximum

being at Corlear's Hook. The ebb, however, varies from 1.4 to 4.4, with a maximum at Fulton Ferry.

Until quite recently the Department had never undertaken any systematic investigation of tidal currents. It is now equipped with an Ellis and a Price current meter operated under the direction of the Surveyor, which automatically records at the surface by an electric indicator the number of revolutions during the period of observation, from which is deduced the velocity of the current in feet per second, or in miles per hour. Thus far, the operations of the Department in this line have been only of an experimental nature. Two stations have been occupied, one at East Fifth Street Pier, the other 830 ft. out from the bulkhead at East Forty-second street. The records show three sets of observations taken within a few minutes of each other at the surface, at mid depth and at the bottom, repeated every half hour from low water to the next high water, and every half hour from high water to the next low water, giving in each instance the time of day and direction of the current, the velocity in feet per second, and the velocity reduced to miles per hour. It is customary to repeat the observations on from three to five consecutive days, noting at each date the direction and velocity of the wind recorded at Pier "A." It requires the watchful care and efforts of three or four able-bodied men to operate one of these meters. The results thus far obtained show a maximum flood current at East Fifth Street of 2.07 miles and at Forty-second Street of 3.26 miles per hour, and a maximum ebb current of 3.13 miles and 4.12 miles per hour respectively at the same stations.

Uses and Occupancy of the Water Front.—Entering the Port of New York and proceeding up the Bay and North River to Spuyten Duyvil, through the Harlem Ship Canal or Harlem River to Hell Gate, up the East River and Long Island Sound to the city limits, and returning south along the East River to Governor's Island, we can rapidly make a survey of the most conspicuous uses of the water front. Passing the extensive excursion resorts at Rockaway and Coney Island, we enter the Lower Bay, noting on the south shore of Richmond the less pretentious excursion resorts of South Beach and Midland Beach, and on our right the anchorage of the Atlantic Yacht Club in Gravesend Bay. We pass in succession the Government fortifications at Fort Hamilton and Fort Wadsworth,

the American Dock Company's piers at Tompkinsville, Staten Island; the Morse Company Iron Works and Floating Dry Docks at Fifty-fifth Street, Brooklyn; the Bush Company docks and railroad terminal from Forty-third to Fifty-first Streets, Brooklyn, where some of the largest tramp steamers discharge and receive their cargoes; the ferry from Thirty-ninth Street, Brooklyn, to Whitehall Street, Manhattan; Gowanus Bay and Canal, with its extensive yacht basins, manufacturing industries and coal pockets; the Erie Basin, with its floating dry docks and graving docks; the Atlantic Basin, with its warehouses, we reach the junction of the North and East Rivers. Making a brief detour through the Kill von Kull, we find the large ship-building industry of Townsend & Downey at Shooter's Island; the Burlee Dry Dock Company at Mariners' Harbor, with numerous manufacturing interests along the north shore of Staten Island, a ferry at Port Richmond to Bergen Point, and the Staten Island Rapid Transit Company's terminal and the Municipal ferry at St. George. Passing up the North River, we find along the stretch from the Battery to Franklin Street, freight and passenger stations of the Pennsylvania Railroad, Lehigh Valley Railroad, the Central Railroad of New Jersey, the Delaware, Lackawanna and Western, the New York Central, the Erie, the Baltimore and Ohio, and the West Shore roads, with the Cromwell, Metropolitan and International Steamship Companies, the Fall River Line, the Liberty Street, Cortlandt Street, Barclay Street, Chambers and Jay Street ferries. Between Franklin and Canal Streets are the Southern Pacific and Old Dominion Lines, the North River steamboats of the Ramsdell and of the Albany Evening Lines, more passenger and freight stations of the Pennsylvania and of the New York Central Railroads, with the Desbrosses Street ferry to Jersey City. The steamship section proper begins at Canal, and, extending to West Twenty-second Street, comprises the Pacific Mail, the Savannah Line, the Southern Pacific, the National, the Atlantic Transport, the French Line, the Clyde Steamship Company, the Quebec Steamship Company, the White Star, Leyland and Cunard Lines, with North River freight boats, the Troy Evening Line, the Patten excursion steamboats, the Albany Day Line and the Christopher Street Ferry and Recreation Pier adjoining. At Gansevoort Market is the station assigned to oyster boats; between West Twenty-second

and West Twenty-fourth Streets, at the north end of the Chelsea Improvement, are the up-town passenger terminals of the Central Railroad of New Jersey, the Delaware, Lackawanna and Western, the Erie and the Pennsylvania Railroads. Between Twenty-fourth and Forty-second Streets are the Anchor Line, the Hamburg-American, the Panama Railroad, the Italian Line, with freight stations of the Baltimore and Ohio, the Lehigh Valley, the Erie, New York Central and Pennsylvania Railroads, and the West Shore Ferry at Forty-second Street. In this section will be found the center of the hay trade and numerous warehouses; north of Forty-second Street to Riverside Park, the piers are mostly used by vessels carrying live stock, coal, ice, brick and cement, with a recreation pier at Fiftieth Street, the principal Department yard between Fifty-sixth and Fifty-eighth Streets, and the largest freight station and grain elevator of the New York Central Railroad. From Seventy-second Street north to One Hundred and Thirty-fifth Street the only piers, of any importance, are those at Seventy-ninth, Ninety-sixth and the piers on the Claremont Section, north of Grant's Tomb. These latter piers are Harlem's principal depots for coal, ice and building material. Here, also, at One Hundred and Twenty-ninth Street, is the Harlem station for excursion steamers and North River freight and passenger service, combined with a recreation pier. The Riverside and Fort Lee Ferry Company operates a ferry at One Hundred and Thirty-first Street.

Continuing on up the North River, we find the shore assuming a character more and more difficult of development on any economical lines, owing to the high and steep nature of its topography. This condition prevails practically all the way to Spuyten Duyvil, with a pronounced break at Dyckman Street. In this section, however, are to be found a number of open river baths, notably at One Hundred and Forty-ninth and One Hundred and Fifty-fifth Streets. Before entering the Harlem River, a glance to the northward along the Hudson River shore of the Bronx reveals a stretch of about three miles, extending to the City of Yonkers, almost entirely unimproved, and, except in two or three places, difficult of commercial development, owing to the steep topography; fortunately, at present there is comparatively little need for wharfage facilities in this section.

Passing, now, through the New York Central Swing Bridge at

Spuyten Duyvil, we enter the Harlem Ship Canal and find a radical change in the old creek from the sinuous stream that used to mark the course of the Harlem River, north of Farmer's Bridge. The minimum width of the canal occurs in a rock cut at Broadway, called Dyckman's Cut. The Government project contemplated a canal 400 ft. wide, with a depth of 15 ft. at low water, except at Dyckman's Cut, where it is 350 ft. wide, with a depth increased to 18 ft. It may be interesting to note that a rather extensive mud flat, just west of the cut, called "Bell Pumpkin," was left by the Government to be taken care of by the tidal currents, and the anticipation of the Government engineers seems to be well founded, as this mud bank is gradually disappearing by erosion. Up to date, the work on the Harlem Ship Canal has afforded a channel nowhere less than 100 ft. wide, or of a less depth than 12 ft. at mean low water. This canal is of the very greatest importance to the city at large, but more particularly to the Bronx and to the northern end of Manhattan. With it in full operation, it is possible for canal-boats to reach the East River by breaking tows at Spuyten Duyvil, thus obviating the necessity of going around the congested district at the Battery.

Up to the present time there has been but little development along the Harlem River, for commercial purposes, between Spuyten Duyvil and Macomb's Dam Bridge, due largely to the fact that the city's ownership in the riparian rights is very much limited. At Two Hundred and Eighteenth Street is the landing slip for coal and the disposal of ashes for the Third Avenue Power Station. At Fordham Heights the city has built a pier which affords the principal means of access for coal and building material to the upper portion of the Bronx. At Sherman's Creek, on the Manhattan side, the city has built a marginal street, skirting the northerly side of the creek and connecting with Academy Street, affording a line of wharfage about 1 300 ft. long. A number of boat clubs find accommodations within Sherman's Creek. At Morris Heights are the manufacturing plant of the New York Yacht and Launch Company and the Charles L. Seabury Yacht Company, where some of the torpedo-boats of the United States Navy have been recently built. On the Manhattan side of the river from this point south to the Manhattan Elevated Railroad terminal at One Hundred and Six-

tieth Street, the water front is flanked by the Harlem River Driveway. Between the New York and Putnam Railroad track and the new Macomb's Dam Bridge, on the Bronx side, we find quite a colony of boat houses connected with the Harlem River Rowing Association. Below Macomb's Dam Bridge most of the improvement is along the Bronx shore and of a private nature. Here we find the solid pier and open-slip or basin construction so well adapted to the conditions prevailing in the Harlem River. The city has built piers of this nature just north of the Madison Avenue Bridge, on the Manhattan side, with new bulkheads and basins at One Hundred and Thirty-fifth Street and again at One Hundred and Thirty-second Street. The accommodations, mostly private, along this portion of the Harlem River provide for general wharfage, principally lumber, coal and building material. On the Bronx side, between the New York Central Railroad Bridge and the Third Avenue Bridge, is the Harlem terminal and transfer station of the Lehigh Valley Railroad. The most important dumping station of the Department of Street Cleaning for the Borough of the Bronx occupies the entire bulkhead at the foot of Lincoln Avenue.

Proceeding easterly, we come to the extensive car yard of the freight terminal and transfer station of the New York, New Haven and Hartford Railroad Company, which occupies the entire water front on the Bronx side, from Second Avenue Bridge as far east as St. Anne's Avenue, a distance of over 3 000 ft. The easterly portion of this water front is on the Bronx Kills, which will not be navigable for vessels until the Federal Government carries out the work of improvement which has long been contemplated. At this point, the New York, New Haven and Hartford Railroad Company makes its transfer of express trains between Boston and Washington, to and from the Pennsylvania Railroad, by means of the large railroad transfer ferryboats *Express* and *Maryland,* which convey on regular schedules entire trains up and down the East River and around the Battery, between the Pennsylvania Railroad Station at Jersey City and the Willis Avenue yard. The remainder of the Harlem River, from Third Avenue Bridge to One Hundredth Street, on the Manhattan side, is occupied by a few short piers, owned mostly by private parties, used for general wharfage and for handling coal. The city has built six piers, one of them a recreation pier, at the foot

of One Hundred and Twelfth Street, and is about to erect three additional piers in this locality. The pier at One Hundred and Sixteenth Street is used by the Manhattan State Hospital, while the principal station of the Department of Street Cleaning, for the dumping of Harlem's ashes and garbage, is at One Hundred and Tenth Street. The easterly shore of the Harlem River, along this section, comprises Randall's and Ward's Islands, and is not available for commercial purposes. On Randall's Island is located the House of Refuge for Juvenile Delinquents, and on Ward's Island the State institutions constituting the Manhattan State Hospital for the Care and Treatment of the Insane.

Passing now, through Hell Gate and up the East River, the first important signs of activity occur at Port Morris, where private enterprise has erected bulkheads for general wharfage and the handling of coal for the Central Union Gas Company. A recently established ferry runs from the foot of One Hundred and Thirty-fourth Street to College Point and North Beach. The Department has built a new pier at One Hundred and Thirty-second Street, which serves as a station for the Department of Health for the transfer of contagious disease cases to the isolation camp and hospital on North Brother Island.

The New York Central and Hudson River Railroad has a freight terminal at One Hundred and Forty-first Street, operating in connection with its Port Morris branch. At Oak Point the New York New Haven and Hartford Railroad has a large car yard and freight transfer terminal operating in connection with the Portchester branch.

The Bronx River, Westchester Creek and Eastchester Creek afford valuable inland waterways for local business, and in a few years will doubtless be developed on these lines, although at present there does not seem to be much demand for their immediate improvement.

Continuing eastward and noting the work of filling in and reclamation in progress by the Department of Street Cleaning at Riker's Island, which, when completed, will result in converting the original area of 87½ acres into an island containing 298 acres, we pass the Government fortifications at Fort Schuyler and Willett's Point, and enter the open Sound. As far as the eye can reach, both

the Bronx and Queens shores seem to exist in the same condition of nature which has prevailed for ages, unmarked by any important defacement in the shape of water front improvement, save at City Island, where a few small shipyards flourish.

Retracing our course and proceeding southward along the Queens shore, the most conspicuous signs of activity appear at the excursion resort at North Beach, and at Lawrence's Point, where the Astoria Heat, Light and Power Company is carrying on an improvement which will reclaim hundreds of acres and wipe out Berrian's Island by absorption with the main land.

From this point south to Newtown Creek the principal features of development along the Queens front are a few private manufacturing industries, with the main receiving and distributing station of the Standard Oil Company on Eleventh Street Basin and the Long Island Railroad terminal at the mouth of Newtown Creek.

Along the Manhattan shore of the East River we note the ferry at Ninety-ninth Street to College Point, the ferry at Ninety-second Street to Astoria, the water-front park from Eighty-fourth to Eighty-ninth Street, and a long stretch of improvement now in progress from Sixty-fourth to Eighty-first Streets, where the Department is building an exterior street, about a mile in length. Owing to the rapidly sloping bottom, great depth of water and swift current, caused by the contraction in the river due to the location of Blackwell's Island in mid-stream, piers are impracticable along the line of this improvement. From Sixty-second Street south to Twenty-third Street there are numerous coal pockets, nineteen piers built by the city and used for general commercial purposes, as well as for excursion and Sound steamers in some cases; the bulkheads north of Forty-second Street, used for the landing of live stock by some of the largest dressed-beef companies; a ferry at Forty-second Street to Broadway, Brooklyn; the Edison Electric Light and Power Station at Thirty-eighth Street; the Long Island Railroad ferry at Thirty-fourth Street; the Charities Department Station at Twenty-sixth Street pier; the largest recreation pier on the water front at Twenty-fourth Street, and the Department's East River yard, between Twenty-fourth and Twenty-fifth Streets, with the New York Yacht Club anchorage opposite, outshore.

Crossing the river to Brooklyn, we find Newtown Creek, extend-

ing four miles inland, between the Boroughs of Brooklyn and Queens, with a depth of water of 12½ ft. at the mouth and about 4 ft. at the head of navigation, with Dutch Kills branching from the north side of the creek into the Borough of Queens, and Whale Creek from the south side into the Borough of Brooklyn, at a short distance from its mouth. This water front provides general commercial facilities for a rapidly growing section of Brooklyn. About the only improvements along the Queens shore of the creek are those made by the Long Island Railroad Company, in connection with its large car yard, but the Brooklyn shore is given up to general wharfage, the Standard Oil Refinery and manufacturing interests allied thereto.

The section between Newtown Creek and Bushwick Creek, known as Greenpoint, was the original seat of ship-building interests in the neighborhood of New York City. It was on this water front that the famous *Monitor* was built. This portion of the water front is, however, now abandoned to the use of general wharfage, with a ferry at the foot of Greenpoint Avenue to Twenty-third Street and to Tenth Street, Manhattan. The city has recently rebuilt a pier at the foot of Noble Street, which is largely used for the transportation of lumber, dressed and undressed, and building materials. At Bushwick Creek we find a somewhat neglected inland stream used, however, for the general storage of oil by the Standard Oil Company along the south shore.

Between Bushwick Creek and the Wallabout Basin the principal features are the freight-distributing station for Brooklyn, the great sugar refineries of Havemeyer & Elder and Mollenhauer, and coffee warehouses of Arbuckle, together with the Delaware, Lackawanna & Western Wallabout terminals. In this neighborhood also is the only recreation pier outside of Manhattan, at the foot of Metropolitan Avenue. At the foot of Grand Street are the ferries to Houston Street and Grand Street, Manhattan; at the foot of Broadway are ferries to Forty-second, Twenty-third, Grand and Roosevelt Streets, Manhattan.

At the Wallabout, we find the Navy Yard, in the rear of which is the Wallabout Basin, connected with the East River by the Wallabout Channel. The city has built five piers in the basin, two of which are occupied by the Pennsylvania Railroad as a freight sta-

tion, the other three being used for general wharfage purposes for this portion of Brooklyn. The Kent Avenue Basin, or Wallabout Canal, extends for about 1 500 ft. inland from Wallabout Basin, and is used as a place of wharfage principally for lumber, stone and coal.

Between the Navy Yard and the old Brooklyn Bridge, the principal industries using the water front are the Brooklyn Union Gas Company, the coffee interests, general wharfage and a ferry at the foot of Main Street to Catharine Street, Manhattan.

Extending all the way from Fulton Avenue, at the Brooklyn Bridge, south to Atlantic Basin, is the extensive system of piers of the New York Dock Company, affording facilities for a world commerce in the reception and transmission of freight and merchandise from all parts of the world. Here also may be found the largest bonded warehouses on the water front. The entire system of piers has been practically rebuilt within the last five years on modern lines of construction, as practiced in the Dock Department. The system of warehouses, with an intervening long wharf between the piers, and the warehouses for the accommodation of freight cars, is almost ideal in principle. There is very little other business transacted in this section outside of the ferries at Fulton Street to Fulton Street, Manhattan, and to Jersey City, the ferry at the foot of Montague Street to Wall Street, Manhattan, and the ferries at Atlantic Avenue and Hamilton Avenue to Whitehall Street, Manhattan.

Resuming, now, our inspection along the Manhattan shore at Twenty-third Street, the water front bears evidences of a recent improvement by the Department, extending as far south as the reception hospitals for contagious diseases at Seventeenth Street, with the ferries to Greenpoint and Broadway, Brooklyn, at the north end of the improvement. Between Seventeenth Street and Corlears Hook, the principal interesting water front features are the Consolidated Gas Company's works in the vicinity of Fifteenth Street, the Morgan and the Quintard Iron Works at East Eleventh and Twelfth Streets, the ferries to Brooklyn at Tenth, Houston and Grand Streets, the floating dry docks of James Shewan and Sons, and the first recreation pier built on the water front at the foot of Third Street. Turning Corlears Hook and directing our course towards the Battery, we pass several freight stations of the New

York, New Haven and Hartford Railroad Company, the New York Central, the Central Vermont, the Long Island Railroad, the Baltimore and Ohio, and Erie, some of the steamer lines to New England ports, such as the Maine Steamship Company, the Joy Line, etc.; lines to southern ports, like the Clyde, the Mallory, the New York and Cuba Mail, the Spanish Line to Havana, the United States Government Philippine Transport Pier at Wall Street, the Fulton Fish Market and the canal-boat district. Dodging the ferryboats from Catharine Street, James Slip, Roosevelt Street, Fulton Street, Wall Street, all bound for Brooklyn, across this very busy portion of the East River, and cutting across the courses of the ferryboats which leave the foot of Whitehall Street, side by side, for Thirty-ninth Street, Atlantic Avenue and Hamilton Avenue, Brooklyn, and the Staten Island ferryboats bound for St. George, we safely run the gauntlet, with the procession of outward-bound Sound steamers, and, rounding the Battery, we enter the recently constructed breakwater for yachts, launches and other small boats at Pier A, where we land at the boat landing, within easy access of the elevated railroad station at Battery Place.

Summarizing the results of our inspection of the water front for Manhattan, we record for comparison in future years that its occupancy and uses are as follows, in percentages of the water front of each river:

		North River below W. 72d St.	East River below 3d Ave.
I.	Foreign steamship service.....	7.0	0.7
II.	Domestic steamship service.....	11.1	3.2
III.	General and miscellaneous commerce.	38.4	16.3
IV.	Railroad business.....	31.0	5.0
V.	Special kinds of commerce.....	5.0	2.8
VI.	Ferries	6.4	5.6
VII.	City Departments	1.1	5.6
VIII.	Unimproved	0	16.9

I.—The foreign or transatlantic steamship companies berthing in Manhattan comprise:

THE AMERICAN LINE,

For Plymouth, Cherbourg and Southampton.

From Pier No. 15, N. R.

Steamers.	Length.	Width.	Tonnage.
New York.	580	63.3	10 675
St. Paul.	554	63.2	11 000
St. Louis.	554	63	11 000
Philadelphia.	580	63.4	10 795

THE RED STAR LINE,

For Antwerp and Dover.

From Pier No. 14, N. R.

Zeeland.	580	60	12 017
Finland.	580	60	12 760
Vaderland.	580	60	12 017
Kroonland.	580	60	12 760

THE ATLANTIC TRANSPORT LINE,

For London.

From Piers Nos. 39 and 40, N. R.

Minneapolis.	600	65	13 401
Minnehaha.	600	65	13 400
Minnetonka.	600	65	13 398
Mesaba.	482	52	6 833

THE FRENCH LINE,

For Havre.

From Pier No. 42, N. R.

La Lorraine.	580	60	11 869
La Savoie.	580	60	11 884
L'Aquitaine.	515	57	9 060
La Touraine.	535	56	9 132
La Bretagne.	507	52	7 302
Montreal.	356	44	4 000
La Provence.	625		

THE WHITE STAR LINE,

For Queenstown and Liverpool.

From Pier No. 48, N. R.

Teutonic.	582	57.8	9 984
Majestic.	582	57.8	10 147
Celtic.	700	40.9	20 904

Oceanic.	704	41	17 274
Cedric.	700		21 035
Baltic.	725	40.9	23 876
Bovic.	470	53.1	6 583
Cevic.	500	60	8 301

For Gibraltar, Naples, Genoa, Alexandria.
From Pier No. 49, N. R.

Republic.			15 378
Cretic.			13 517
Romanic.			11 394

LEYLAND LINE,

For Hull.
From Pier No. 50, N. R.

Colorado.	370	44.7	4 220
Toronto.			

ALLAN LINE,

For Liverpool.
From Pier No. 50, N. R.

Pommeranian,	381	43.8	4 250
Mongolian.	400	45.2	4 909

CUNARD LINE,

For Liverpool and Queenstown.
From Piers Nos. 51 and 52, N. R.

Campania.	625	65.2	12 950
Lucania.	625	65.2	12 952
Etruria.	518	57.2	8 120
Umbria.	518	57.2	8 127
Coronia.	675	72.5	21 000

For Gibraltar, Naples, Adriatic Sea.
From Piers Nos. 51 and 52, N. R.

Pannonia.	501	59	9 851
Carpathia.	540	64.4	13 564
Ultonia.	500	57	10 402
Slavonia.	526	59	10 605

ANCHOR LINE,

For Glasgow and Londonderry.

From Pier at W. 24, N. R.

Caledonia.			
Astoria.			
Columbia.			
Furnessia.	445	44.5	5 495

BRISTOL CITY LINE,

For Swansea, Wales.

From Pier at W. 29, N. R.

Brooklyn City.	261	34.6	1 660
Chicago City.	295	39	2 324
Jersey City.	270	36	1 890

ITALIAN LINES,

For Naples, Genoa and Alexandria.

From Pier at W. 34, N. R.

Washington.	*Lombardi.*
Nord America.	*Liguria.*
Citti di Torino.	*Sardigna.*
Citti di Genova.	*Monvisor.*
Sicilia.	*Soperga.*

SPANISH ROYAL MAIL,

For Cadiz, Barcelona, Genoa and Naples.

From Pier No. 10, E. R.

Buenos Ayres.	265	36.1	1 783
Manuel Calvo.			

II.—The domestic coastwise steamship companies comprise:

THE CROMWELL LINE,

For New Orleans.

From Pier Old 9, N. R., and Pier at W. 34, N. R.

Steamers.	Length.	Width.	Tonnage.
Creole.			2 362
Hudson.	300	34	1 873
Knickerbocker.	280	33.6	1 642
Louisiana.	349	39	2 840
New Orleans.	270	33	1 564

METROPOLITAN LINE.

For Boston.

From Piers Old 10 and 11, N. R.

General Whitney.	240	40	1 849
H. F. Dimock.	291	41.6	2 626
Herman Winter.	291	41.6	2 626
Glaucus.			1 206

SOUTHERN PACIFIC LINE,

For New Orleans and Galveston.

From Piers Nos. 25, 37 and 38, N. R.

El Sigo.
El Alva.
El Norte, 2 901 tons.
Proteus.
Chalmette, 1 951 tons.
Comus.

OLD DOMINION LINE,

For Old Point Comfort, Norfolk, Portsmouth, Pinner's Point and Newport News.

From Pier No. 29, N. R.

Guyandotte, 1 651 tons.
Jamestown, 2 126 tons.
Old Dominion, 1 776 tons.
Princess Anne, 2 017 tons.
Richmond, 1 102 tons.
Roanoke, 1 655 tons.
Yorktown, 2 126 tons.

OCEAN STEAMSHIP COMPANY,

For Savannah.

From Pier No. 35, N. R.

Chattahoochee, 2 669 tons.
City of Augusta, 2 870 tons.
Nacoochee, 2 680 tons.
Tallahassee, 2 677 tons.

CLYDE LINE,

For Charleston, Jacksonville and West Indies.

From Piers Nos. 36, 44 and 45, N. R., and Piers Old No. 33 and 34, E. R.

Arapahoe.
Apache.
Iroquois.
Comanche.
Seminole.
Cherokee.

QUEBEC STEAMSHIP COMPANY,

For Bermuda, St. Thomas, St. Croix, St. Kitts, Antigua, Martinique, St. Lucia, Barbadoes and Demerara.

From Pier No. 47, N. R.

Panama.
Bermudian.
Trinidad, 2 161 tons.
Manoa.
Korano.
Carribbee, 1 944 tons.
Fontabelle.
Parima.

HAMBURG-AMERICAN LINE,

Atlas Service.

For Jamaica, Port Antonio, Kingston, Savanilla, Cartagena, Limon, Inagua, Port de Paix, Port Au Prince, Colon, Santa Marta, Cape Hayti, Gonaives, Jeremie, Aux cayes, Jacmel, Belize, Porto Barrios, Livingston, Porto Cortez, Port Dietrich.

From Pier at W. 25, N. R.

Steamers.

Flandria.
Sibiria.
Altai.
Sarnia.
Alleghany,

Steamers.

Valdivia.
Adirondack, 2 167 tons.
Alene, 2 293 tons.
Graecia.

PANAMA RAILROAD STEAMSHIP COMPANY,

For Colon, Panama.

From Pier at W. 27, N. R.

Advance.
Finance.
City of Washington.
Seguranca.

SPANISH ROYAL MAIL,

For Havana and Vera Cruz.

From Pier No. 10, E. R.

Mont Serrat, 4 390 tons.
Havana, 2 592 tons.

MUNSON LINE,

For Cuban ports.

From Pier Old 14, E. R.

Curityba.
Cuba.
Vidar.
Olinda.

WARD LINE,

For Havana, Guantanamo, Santiago, Nassau, Mexico.
From Piers Old 16 and 18, E. R.

Niagara, 2 265 tons.
Mexico.
Vigilancia, 4 115 tons.
Santiago, 2 359 tons.
Seneca, 2 729 tons.
Esperanza.
Morro Castle.
Havana.
Yucatan, 3 525 tons.
Orizaba, 3 497 tons.

MALLORY LINE,

For Key West, Mobile, Galveston.
From Piers Old 19, 20, 21, E. R

San Marcos, 2 839 tons.
Comal, 2 934 tons.
Alamo, 2 943 tons.
City of Antonio.
Colorado, 2 765 tons.
Concho.
Lampassas, 2 943 tons.
Leona, 3 329 tons.
Neuces, 3 367 tons.
Rio Grande, 2 566 tons.

MAINE S. S. Co.,

For Portland, Me.
From Pier No. 32, E. R.
North Star.
Horatio Hall.

III.—The general miscellaneous commerce of Manhattan requires accommodations for the business carried on by the various inland water transportation lines, excursion steamers, large dealers in coal, building materials, market supplies, dressed beef, live stock, ice companies, breweries, malting houses, numerous manufacturing industries, dumping boards for excavated material, street sweepings and ashes, manure, etc., baths, boat houses, etc.

The principal lines engaged in regular inland water transportation are:

THE CENTRAL RAILROAD OF NEW JERSEY (Sandy Hook route),

From Piers Old No. 8 and at W. 41, N. R.

THE OLD COLONY, operating the Providence, Fall River and Stonington and Norwich Lines,

From Piers Nos. 18, 19 and 40, N. R., and Pier No. 31, E. R.

THE CENTRAL HUDSON STEAMBOAT COMPANY,
From Pier No. 24, N. R.

THE HOMER RAMSDELL LINE,
From Pier No. 24, N. R.

THE NEW JERSEY STEAMBOAT COMPANY,
From Pier No. 32, N. R.

THE ALBANY EVENING LINE,
From Pier No. 32, N. R.

THE CATSKILL & NEW YORK STEAMBOAT COMPANY,
From Pier No. 43, N. R.

THE SAUGERTIES & NEW YORK STEAMBOAT COMPANY,
From Pier No. 43, N. R.

THE TROY EVENING LINE,
From Pier No. 46, N. R.

THE PATTEN LINE,
From Pier No. 53, N. R.

THE ALBANY DAY LINE,
From Piers at W. 41 and W. 129, N. R.

NEW YORK & BALTIMORE TRANSPORTATION COMPANY,
From Pier at W. 44, N. R., and Pier Old 11, E. R.

HARTFORD & NEW YORK TRANSPORTATION COMPANY,
From Piers Nos. 19 and 33, E. R.

THE JOY LINE,
From Pier No. 27, E. R.

IV. The railroads entering Manhattan by way of the waterfront or which use the waterfront in the transaction of their freight and passenger business are

THE CENTRAL RAILROAD OF NEW JERSEY,
Piers Old 8, 10 and 11, N. R. Liberty Street and West Twenty-second Street ferries.

THE PENNSYLVANIA RAILROAD,

Piers Old 1, 3, 4, 5, New 27, 28, 29, at W. 37 and W. 38, N. R. Cortlandt Street, Desbrosses Street and West Twenty-third Street ferries.

DELAWARE, LACKAWANNA AND WESTERN RAILROAD,

Piers No. 13 at W. 28 and W. 41, N. R. Barclay, Christopher and West Twenty-third Street ferries.

NEW YORK CENTRAL RAILROAD,

Piers Nos. 16, 17, 23, 31, at W. 31, W. 32, W. 33, W. 36, W. 59 to W. 72, N. R., and Piers Nos. 4 and 31, E. R. Harrison Street and West Forty-second Street ferries.

ERIE RAILROAD,

Piers Nos. 20, 21, at W. 49, N. R., and Pier No. 7, E. R. Chambers Street and West Twenty-third Street ferries.

LEHIGH VALLEY RAILROAD,

Piers Old No. 2, and Nos. 44, 45, N. R., and at E. 43, E. 44, E. R. Pensylvania Railroad ferries.

NEW YORK, NEW HAVEN AND HARTFORD RAILROAD,

Piers Old 45, Old 46, Old 49, New 38, Old 50, 51 and 52, E. R.

LONG ISLAND RAILROAD,

Pier at Pine Street, E. R. James Slip and East Thirty-fourth Street ferries.

BALTIMORE AND OHIO RAILROAD,

Piers No. 22, at W. 26, N. R., at Peck Slip and at E. 38, E. R. Staten Island Ferry and Pennsylvania Railroad ferries.

CENTRAL VERMONT RAILROAD,

Pier Old 36, E. R.

HARLEM AND PORTCHESTER RAILROAD,

Pier at Montgomery Street, E. R.

All other railroad lines make their connections to enter the city through these lines.

V.—The special kinds of commerce provided for by law comprise:

THE CANAL BOAT DISTRICTS,

Pier Old 3 to Old 8, E. R., and at W. 51 to W. 54, N. R.

FULTON FISH MARKET,

Piers Nos. 17 and 18, E. R.

FLOATING DRY DOCKS.

THE OYSTER MARKET,

At Gansevoort Market.

MARKET SUPPLIES AND PRODUCE,

At the recreation piers.

At Gansevoort Market.

VI.—The ferries of Manhattan are:

North River.

Liberty Street to Jersey City—Cent. R. R. of N. J.

Cortlandt Street to Jersey City—P. R. R. Co.

Barclay Street to Hoboken—D., L. & W. R. R. and Hoboken Land and Improvement Co.

Chambers Street to Jersey City—Erie R. R. Co.

Harrison Street to Weehawken—West Shore R. R. Co.

Desbrosses Street to Jersey City—P. R. R. Co.

Christopher Street to Hoboken—D., L. & W. R. R. and Hoboken Land and Improvement Co.

West Twenty-second Street to Jersey City—C. R. R. of N. J.

West Twenty-second Street to Hoboken—D., L. & W. R. R.

West Twenty-third Street to Jersey City—Erie R. R. Co.

West Twenty-third Street to Jersey City—P. R. R. Co.

West Forty-second Street to Weehawken—West Shore R. R. Co.

West One Hundred and Thirtieth Street to Riverside—Riverside and Ft. Lee Ferry Co.

East River.

Liberty Island Ferry to Liberty Island—U. S. Government.

Governor's Island Ferry to Governor's Island—U. S. Government.

Staten Island Ferry to St. George, S. I.—Municipal ferry.

South Ferry to Atlantic Avenue, Brooklyn—Union Ferry Co.

Hamilton Ferry to Hamilton Avenue, Brooklyn—Union Ferry Co.

South Brooklyn Ferry to Thirty-ninth Street, Brooklyn—New York and Brooklyn Ferry Co.

Wall Street to Montague Street, Brooklyn—Union Ferry Co.

Fulton Street to Fulton Street, Brooklyn—Union Ferry Co.

Roosevelt Street to Broadway, Brooklyn—Brooklyn Ferry Co. of New York.

James Slip to Borden Avenue, Long Island City—Long Island R. R. Co.

Catharine Street to Main Street, Brooklyn—Union Ferry Co.

Grand Street to Grand Street, Brooklyn—Brooklyn Ferry Co. of New York.

Grand Street to Broadway, Brooklyn—Brooklyn Ferry Co. of New York.

Houston Street to Grand Street, Brooklyn—Nassau Ferry Co.

East Tenth Street to Greenpoint Avenue, Brooklyn—Brooklyn Ferry Co. of New York.

East Twenty-third Street to Greenpoint Avenue, Brooklyn—Brooklyn Ferry Co. of New York.

East Twenty-third Street to Broadway, Brooklyn—Brooklyn Ferry Co. of New York.

East Thirty-fourth Street to Borden Avenue, Long Island City—Long Island R. R. Co.

East Ninety-second Street to Fulton Street, Astoria—New York and East River Ferry Co.

East Ninety-ninth Street to College Point—New York and College Point Ferry Co.

The remaining ferries of New York City are:

The East One Hundred and Thirty-fourth Street Ferry to College Point—New York and College Point Ferry Co.

The Fulton Street Ferry, Brooklyn, to Jersey City—Pennsylvania R. R. Co.

The Port Richmond Ferry to Bergen Point—The Port Richmond and Bergen Point Ferry Co.

VII.—The occupancy of the Manhattan water front by City Departments comprise:

Park lands and driveways under the control of the Park Department:

Riverside Park.
Fort Washington Park.
Harlem River Driveway.
Thomas Jefferson Park.
East River Park.
Hamilton Fish Park.

Piers and bulkheads assigned to the:

Department of Health.
Fire Department.
Department of Charities.
Department of Correction.
Department of Street Cleaning.

Operations of the Bureau of Construction and Repairs.

Dredging.—It is seldom necessary to dredge over the site to be occupied by new piers, except in such cases that involve the removal of old work, in the nature of old cribs, and also at locations where a proper depth of water must be made in order to float the pile drivers or other floating plant during the work of construction. The principal work of dredging, therefore, is in the preparation of the foundations for the bulkhead or sea wall, dredging for crib bulkheads and for the maintenance of a proper depth of water in the slips. For work connected with the construction of the bulkhead wall, dredging is usually carried to about 30 ft. over the area involved, unless the character of the bottom is such that the wall can be founded upon rock within a reasonable depth, usually a maximum of 40 ft. below mean low water, in which cases all material is removed by a dredge preliminary to pumping off the rock by the plant of the Department. Where dredging is carried down to rock in preparing the foundation for a rock section of the bulkhead wall, all the material that can be removed by a clam-shell bucket is so removed, after which the area is gone over with a dipper transversely and longitudinally, every care being taken to remove all of the material practicable with the dredge, as the sub-

sequent operation of pumping and cleaning off rock is very expensive.

Slip dredging or dredging for the accommodation of vessels is a continuous process, some slips, owing to the more rapid silting up, requiring more frequent dredging than others. The depth of water required in slips varies all the way on the North River from 15 to 40 ft., and from 10 to 30 ft. on the East River, depending upon the draft of vessels. Where excessive depths are required, that is, from 25 to 40 ft., it is not customary to dredge closer than within 25 ft. of a pier structure, in order to prevent the exposure of too great a length of piles above the mud bottom.

The Gansevoort and Chelsea Sections, that is, the territory lying between West Eleventh and West Twenty-second Streets, where the largest steamships are berthed, are the only localities at which a depth of 40 ft. is required.

The rate of silting up of slips is about 2½ ft. per year on the North River, and half of this amount on the East River. The Department has no dredging plant of its own, and is, therefore, obliged to contract all of this work.

The clam-shell dredges are about 31 ft. wide and 82 ft. long, with a draft of about 7 ft. and a bucket capacity of from 4½ to 7 cu. yd. The scoop dredges vary from 35 to 41 ft. in width and from 93 to 104 ft. in length, with drafts of from 6 to 8 ft., the capacity of the dippers being about 5 cu. yd. The clam-shell bucket used on any dipper dredge has a capacity one-third more than its largest dipper.

The scows used for conveying the dredged material to sea are from 32 to 40 ft. wide and from 110 to 200 ft. long, varying in capacity from 300 to 1 700 cu. yd. The first steel mud scow is now under construction by R. G. Packard, and will have a capacity of 1 800 cu. yd. On December 6, 1904, one of the largest dredges in the harbor loaded a twelve-pocket scow with 1 700 cu. yd. in two hours, dredging to a depth of 40 ft. This machine can average 600 cu. yd. per hour and depend upon it. The dipper has a capacity of 10 cu. yd., and is operated with a boom consisting of one stick of Oregon pine, 82 ft. long and 40 in. square. The spuds for this dredge are 5 ft. square, made up of four 80-ft. sticks. These dipper dredges never stop for any kind of obstruction short of solid rock.

Owing to the fact that all scows must be taken to sea and dumped, the price for dredging will vary somewhat according to the haul. Mud dredging on the North River for depths of from 10 to 35 ft. costs about 16½ cents per cu. yd, and from 27 to 29 cents on the East River.

Miscellaneous dredging, including upland, made land and buried cribwork to a depth of 30 ft., costs about 42 cents per cu. yd. and 46 cents to a depth of 40 ft. Crib dredging is the most expensive dredging and costs from 72 cents to $1 per cu. yd.

There is considerable routine involved in the passing of an estimate for dredging, surrounded with every check, both by the Department and by the Supervisor of the Harbor, against fraudulent disposal of the material. The Supervisor of the Harbor and the Inspectors patrol the ocean dumping grounds, and their examination of the scows is made at sea. If a scow is taken to sea with one or more pockets empty, that fact is immediately communicated to the Engineer-in-Chief of the Department, and the necessary deduction in volume is promptly made. It frequently happens that a scow goes to sea and is compelled to return with one or more pockets undumped, owing to the jamming of the dredged material, as, for instance, crib logs. In such cases the scow returns with the undumped pocket, and the material is dumped on the site of the work and redredged. A careful record is kept of this matter, so that the materials thus dumped at the dredged area shall not be paid for until legally disposed of. If, on the other hand, the Supervisor of the Harbor reports that a certain scow returns from the dumping ground at sea with a certain pocket undumped, and the scow on its return to the site of the work should be found to have this pocket empty, the only inference to be drawn is that somewhere on the route between the dumping ground and the site of the work this pocket has become unloaded, and the amount of material charged to this pocket on the daily report for dredging is deducted from the amount of dredged material, unless the dredging company can satisfy the Supervisor of the Harbor that the material in that pocket was legally disposed of somewhere else, and if the Supervisor clears the scow on the statement of the dredging company, the material is paid for by the Department as dredged and properly disposed of.

All material is paid for, as a rule, by scow measurement, unless

FIG. 1.—HEADQUARTERS OF DEPARTMENT OF DOCKS AND FERRIES, PIER A, N. R.

FIG. 2.—PIER NO. 1, N. R. (MASONRY PIER).

it is of such a nature that it can be rafted, when it is measured in bulk on rafts before leaving the site of the work. Cribwork that can be definitely measured in advance is paid for by place measurement.

During the year 1904 the dredged material taken to sea and dumped under the Department contracts amounted to 2 407 000 cu. yd. at a cost of $833 800, averaging about 35 cents for all classes.

Pier Construction.—The predominating motive in designing a pier should be the preparation of a landing stage to serve as an intermediary in the handling and in the reception and transmission of freight and merchandise between water and land transportation. It is in no sense either a storehouse or a warehouse. As a landing stage it must be low enough to accommodate the convenient loading and unloading of a vessel at extremely low tide and yet be high enough to avoid being awash at extremely high water. The established height of piers and bulkheads was long ago adopted in the Department at 5 ft. above mean high water, or at a grade of about + 9.25, and after an experience of thirty-five years, the Department sees no good reason for deviating from this practice. In construction, it must be elastic rather than rigid, and were it not for their perishability, the wooden piers as now constructed would be almost ideal. When the Department began its operations at the beginning of its career, it was decided to build most of the piers of masonry or of some equally durable material; but the best commentary on this attitude is the fact that after a lapse of over thirty years but two masonry piers have ever been attempted by the Department; one of them, Pier A, Plate XXVI, Fig. 1, completed in 1885, was built as a foundation for the permanent headquarters of the Department and not as a pier for wharfage. The only legitimate masonry pier, therefore, on the water front is Pier No. 1, next north of Pier A, at the foot of Battery Place, Plate XXVI, Fig. 2. This pier, owing to its rigid construction, is about the poorest renting pier on the water front. Steamship captains are loth to wharf their vessels at such a pier when anything else is available; nor is their objection unreasonable, for when we realize that the impact of a vessel of 10 000 tons displacement, moving with a tidal velocity of, say, two miles per hour, develops nearly 3 000 000 ft-lb. of accumulated work, which must be neutralized in bringing the vessel to a

stop, it is easy to conceive that as between a rigid pier and a steamship this quantity of work must be expended in distortions in the more elastic structure. Such a pier, that is, a rigid pier, however, may be made more available by adopting an elaborate system of elastic fendering, which, on the other hand, involves a diminution of slip area or slip width, and the use of long and unwieldy gangways.

The pier in question was begun in the fall of 1872 and completed in the fall of 1876. It consists of 18 arched spans, supported upon abutments built of concrete blocks founded upon the rock bottom, which varies from 23 to 50 ft. below mean low water. The exposed surfaces of arches and spandrels on each side of the pier are faced above mean low water with granite, with a concrete filling, to asphalt grade. The pier cost more than half a million dollars, or $14 per sq. ft., about seven times the cost of a timber pier such as would be required at this locality, that is, a crib block and bridge pier, for a pile pier at this location would be impracticable.

Masonry piers are, therefore, virtually prohibitive both in time and money. There are three factors which seem to control the choice of materials to be used in pier construction—rapidity of building, facility with which extensions, widenings and repairs may be made, and its commercial life, the latter being independent of its durability. The average life of a timber pier is between thirty and forty years on the North and East Rivers, and it appears that before a pier reaches its limits of durability it will more than likely have outlived or outgrown its usefulness, and will have to be replaced with a more modern structure. It, therefore, seems that timber best fulfills these three requirements, all other things being equal. But we are rapidly approaching a period when the Eastern forests will have yielded up their supply of timber, and we shall be obliged to look to the forests of the Northwest for material, a contingency that will undoubtedly involve some very interesting problems in transportation. Already the air is filled with the hum of "reinforced concrete," but this admirable combination of materials has its limitations. At present, an 80-ft. pile driven and cut off in the work costs from $18 to $20, and in case such a pile could not furnish the frictional resistance required, the pile can be lagged so that it will drive to refusal in a mud bottom, and would cost about $28. A concrete-steel or ciment armé pile, supported by sur-

face friction would have but little more efficiency than a lagged pile, and would cost in the neighborhood of $200.

While on the subject of piles it may be interesting to note that the sewage pollution of the waters of the North and East Rivers has driven away the teredo, and there is little to fear from the ravages of this destructive form of animal life between Lawrence's Point and Governor's Island. But in localities washed by the clean, unpolluted sea water, the creosoting of piles will most likely serve as an efficient safeguard at least for a period sufficient to cover what might be called the commercial life of a pile structure.

In 1889 an examination was made of the timber columns in the outer end of Pier No. 46, North River. In the early pier construction of the Department the outer four or five rows were not built on piles, but on what were called columns consisting of four 10-in. by 10-in. yellow pine sticks bolted and tree-nailed together to form what was called a column. This pier was built in 1875. From the report of the diver, who made the examination, it appears that the columns were badly eaten, making it possible to encircle each of the four stocks with the clasped hand, the remaining timber being in some cases not more than 20% of the original cross-section; the maximum diminution in section being near the mud line, the loss gradually becoming less up to near low water. The same diver reported that all the piles in the pier were in excellent condition, free from honeycomb, and in many cases covered with bark.

The general principles of pier construction have varied but little during the past thirty years; but the modern pier of the Dock Department is somewhat of an evolution, differing in many details from the earlier piers. The piles are driven in transverse rows 10 ft. apart, spaced about 6 ft. on centers in the rows. The outer about 60 ft. of a pier comprises what is called the double-row system. The pile rows are double, with double the number of piles in each row, and are on 23-ft. centers, to provide a wider waterway for the passage of ice and a freer flow of sewage, which is carried out and discharged in the double-row system from circular or elliptical conduits built in the substructure of the pier of 4-in. creosoted spruce or yellow pine staves connecting at the bulkhead with the street sewer. With the exception of the fender system, all of the lumber in a pier is generally Southern long-leaf yellow pine of the Savan-

nah merchantable inspection (Plate XXVII). The side bearing piles of a pier are capped with 12 by 12-in. sticks in about 30-ft. lengths, joined with 4-ft. scarfs. The transverse rows are clamped at a level 1 ft. higher than the side caps with two 6 by 12-in. sticks in the single row system, with heavier clamping in the double-row system. Each pile row in the single-row system is braced horizontally at mean low water with a 5 by 10-in. stick, and diagonally with what is termed "A" bracing of the same size lumber between the horizontal brace and the clamp system. In the double-row system a center sheathing or horizontal planking of 6 by 12-in. lumber extends continuously across the pier from mean low water to the clamp system. The outer end of the pier is sheathed horizontally with 4 by 10-in. planking, outside of which is a 5 by 10-in. vertical sheathing, extending from low water to the top of the backing log. The floor system consists usually of 4 by 10-in. planking laid transversely across the ranger system, which consists of a pair of 6 by 12-in. sticks, separated half an inch, and extending longitudinally the entire length of the pier to the double-row system in as many rows as there are piles in a row. In the double-row system the rangers are 12 by 12-in. sticks, doubled up vertically and horizontally, firmly chocked over the double rows with solid chocking between the rangers. The deck is covered with a 4 by 10-in. sheathing generally laid in a narrow longitudinal strip along each side of the pier with a center strip laid diagonally. The sides and outer end of the pier are provided with a 12 by 12-in. backing log, popularly termed the string piece. Both ends of each double row are protected with armature plates of ½-in. boiler iron. The pier is further braced with an inclined pile at each end of alternate rows, excepting in the double-row system, which has two such piles at each end of each row, excepting in the outer row.

The standard fender system of a pier comprises a vertical oak pile driven at the outer end of each row, along both sides of the pier, and chocked between with horizontal and vertical chocking pieces.

The usual appurtenances of a pier comprise cast-iron cleats, single bitts and large corner mooring posts bolted to the pier structure. All parts of the pier are securely fastened with dock spikes.

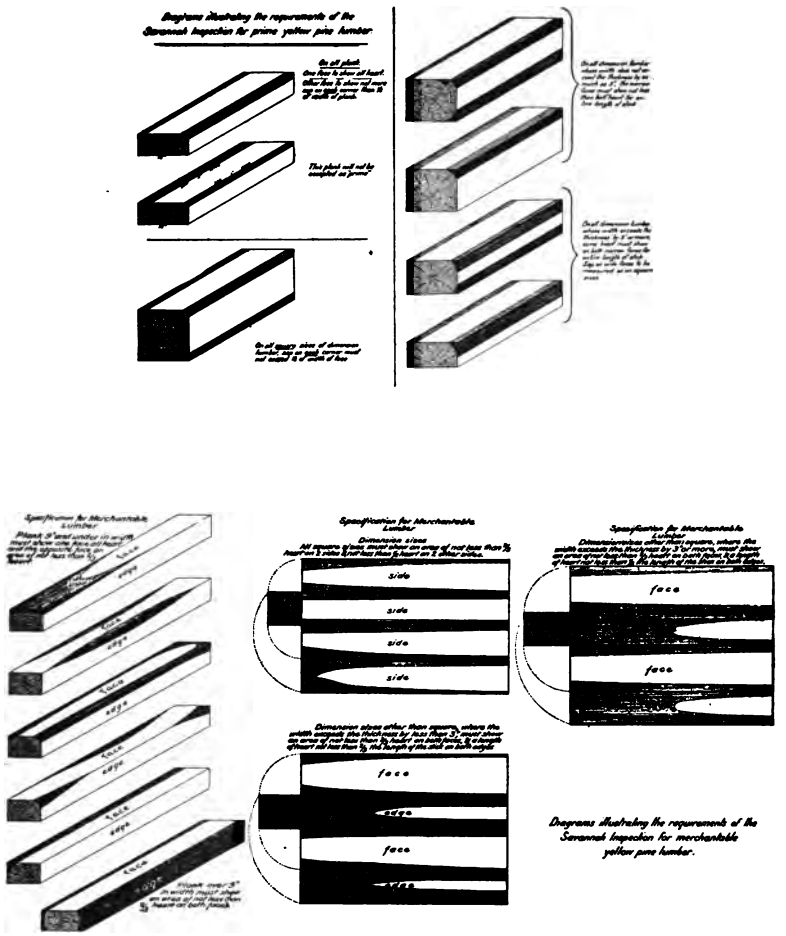

Diagrams illustrating the requirements of the Savannah Inspection for prime yellow pine lumber
Specification for Merchantable Lumber
Dimension sizes
All squares when sized shall not vary of not less than ⅝ inch from the thickness specified, and ⅞ inch when over 6 inches.
side
face
Diagrams illustrating the requirements of the Savannah Inspection for merchantable yellow pine lumber.

FIG. 2.

PLATE XXVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

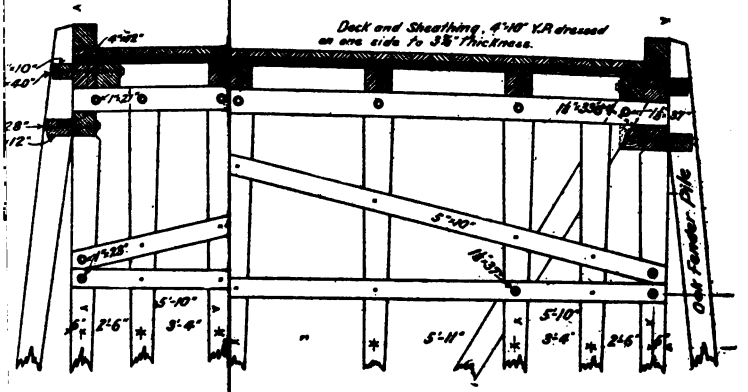
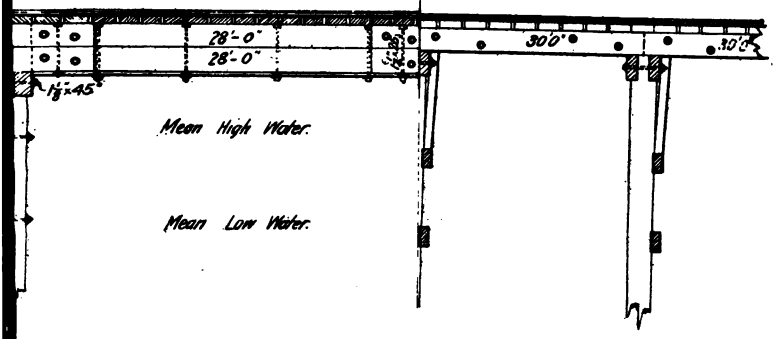


PLATE XXIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

Longitudinal Section.



General Plan.

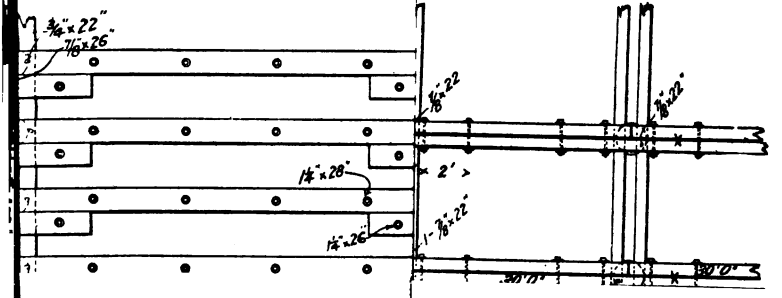
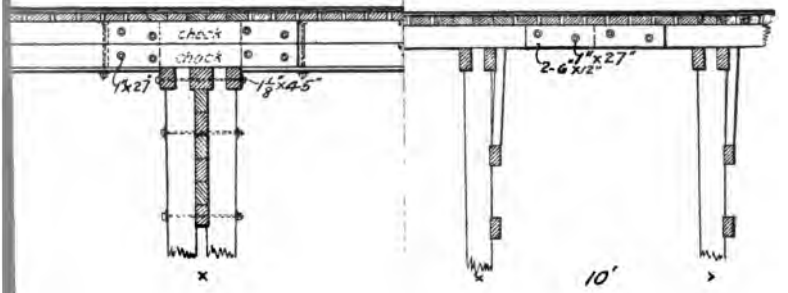


PLATE XXX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

Longitudinal Section.



General Plan.

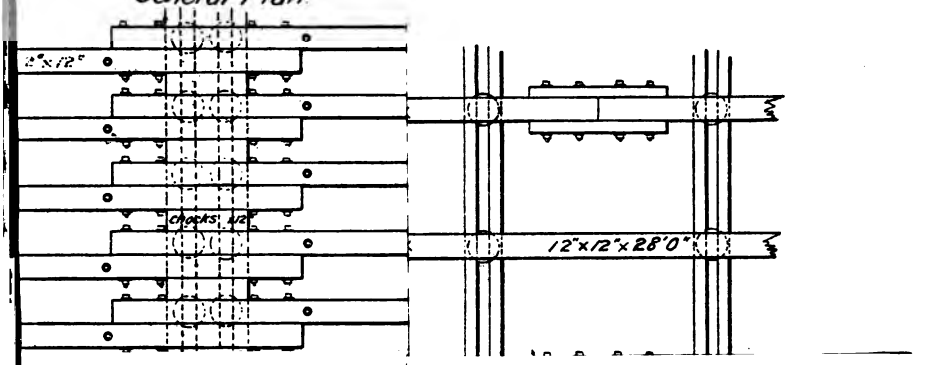
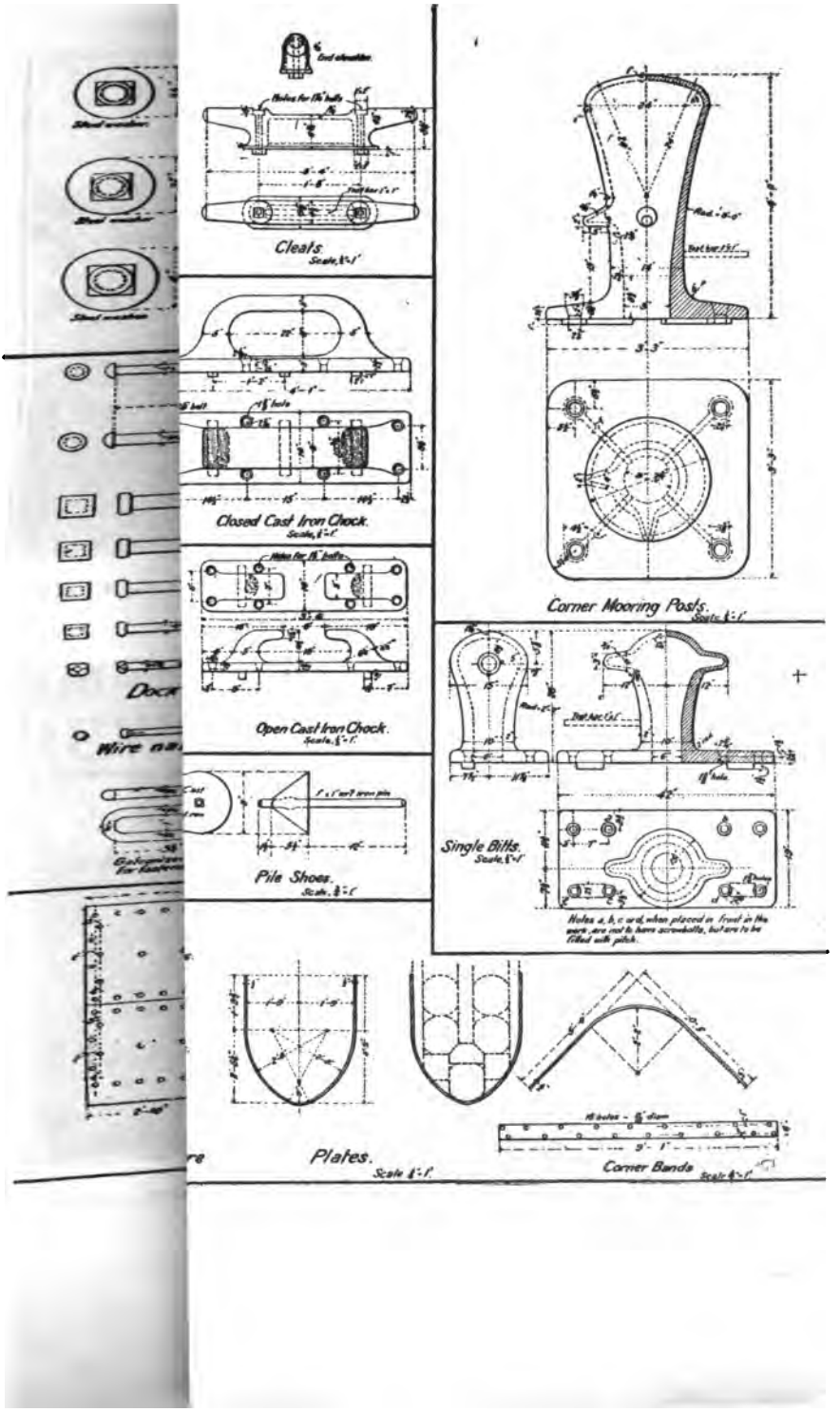


PLATE XXXI.
THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK DOCK DEPARTMENT.



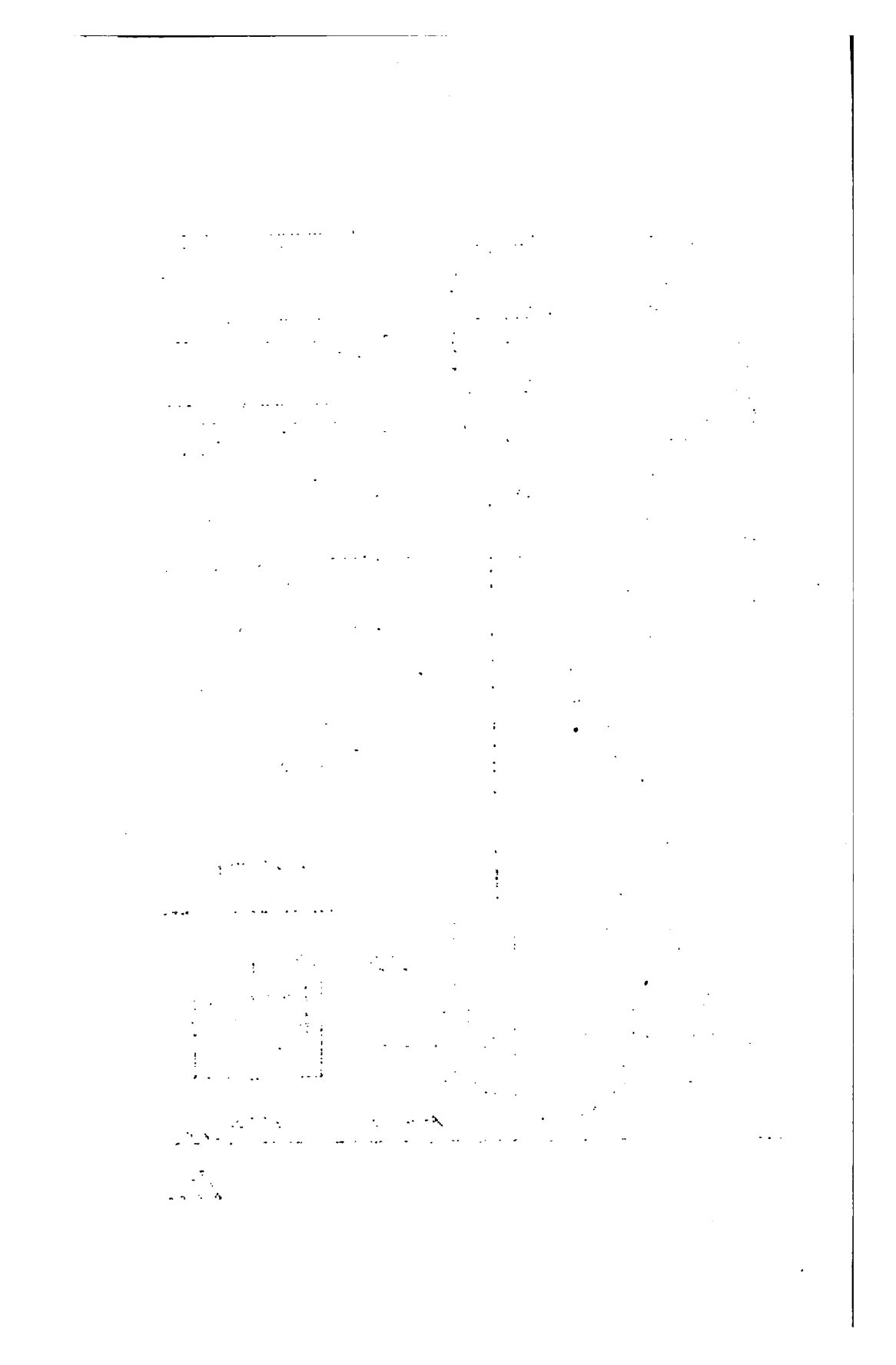


FIG. 1.—PIER NO. 24, N. R., SHOWING EFFECT OF COLLISION OF FRENCH LINE STEAMER *La Bretagne*.

FIG. 2.—PIER NO. 24, N. R., SHOWING OUTER END PUSHED 10 FEET SOUTH BY COLLISION OF FRENCH LINE STEAMER *La Bretagne*.

ranging from ½ by 10 in. to ⅞ by 28 in., and screw bolts ranging from 1 to 2 in. in diameter, and varying in length from 12 in. to 7 ft. All joints in timber and all bearings where one timber crosses another are liberally treated with Wilmington tar or dead oil. The heads of piles of the clamp system are treated with asphaltic cement. No attempt is made in this paper at a minute or detailed description of a pier, as that in itself is ordinarily a sort of treatise on the subject, and appears in full in the Department specifications. A more intelligent idea can be obtained from the drawings. (See Plates XXVIII, XXIX, XXX and XXXI.

A reference to Plate XXXII will show the advantage of timber construction in piers of the type built by the Department of Docks. On December 10, 1892, the French Line steamer *La Bretagne* had backed out of its slip at Pier No. 42, N. R., and in turning down stream outward bound, it had not gotten under sufficient steerage way to prevent a collision with Pier No. 24. It struck the northerly side of this pier about 80 ft. from the outshore end and cut through the structure in a southeasterly direction to within about 15 ft. of the southerly side. The outer 100 ft. of the pier was moved southerly about 10 ft. After repairing the damage done in the *crevasse* made by the collision, which reduced the heavy timber to matchwood, the outer portion of the pier was bunted back into position by tugs, and the deck and sheathing relaid. This could hardly have been done with any other type of structure.

The above description is very general, and takes no account of the elaborate chocking, framing of timber, fastenings and extra timbers and piles for shed foundations which enter into the construction of a substantial pier. The extensive piers at present under construction in the Chelsea Section are probably the highest type of pier construction yet reached by the Department, the principal variations from standard construction appearing in the extra strengthening of the pile rows by means of doubled-up horizontal braces, reinforced diagonal bracing at the ends of the rows, and a heavy chocking of the end pile in each row, by means of which a lateral thrust is transmitted to the interior piles of a pier through a chocking between the pileheads; the large rounded corner is a solid construction of piles and timber (see Plate XXX), sheathed on the outside with close vertical fendering of 10 by 10-in. yellow

mean low water, on 33-ft. centers, giving at the floor system an open span of about 22 ft. between adjacent blocks. The cribs are finished off above mean low water with a square timber trestle work, which serves as abutment piers for the 22-ft. bridge span, which is part of the floor or deck system, and which is carried continuously from end to end of the pier. The caps of these trestles are usually doubled up, in conjunction with provisions for wedging up and blocking up to grade from time to time, due to any possible subsequent settlement in any of the crib blocks. The outer end block is usually a solid-built crib throughout with a square timber face. The outer end and sides of such a pier are fendered in a manner similar to a pile pier.

The cost of piers of this type is about $1.50 per sq. ft.

The solid-filled crib pier consists of nothing more than a round log rock-filled crib with square timber face above mean low water, built along the sides and across the outer end, with a solid filling of earth or ashes behind the cribs to grade. The cost of such a pier depends almost solely upon the dredging and cribwork, as the filling costs nothing, as a rule. Dredging for the cribs should be carried to hard bottom and below the depth required in the slip. It would be misleading to attempt to estimate the cost per square foot; for a pier 200 ft. wide would cost only so much more than a pier half its width as the extra 100 ft. of cribwork would cost. In other words, the cost is, in this case, a function of the wharfage room and, depending upon the depth of the dredging, will average about $42 per lin. ft.

Piles.—Pier piles are required to be sound and straight white pine, yellow pine, Norway pine or cypress, with at least 6-in. points, and butts to cut off usually not less than 16 in. in the double-row and 15 in. in the single-row system. They are driven usually until they refuse to penetrate more than 1 in. per blow under the last 10 blows of a 3 000-lb. hammer, falling 10 ft. The pier piles are distributed to carry a safe load of 15 tons per pile. Extra piles for freight-shed foundations are distributed to carry from 12 to 15 tons per pile, depending upon the nature of the bottom. In the piers of the Gansevoort Section, most of which have double-deck freight sheds, the foundations were designed to carry 12 tons per pile, the bottom being over 100 ft. of mud. The piles were 80 ft.

long and drove 6 in. under the last blow of the hammer. According to the *Engineering News* formula, these piles are only good for a safe load of 4¼ tons. None of these piers have shown any appreciable settlement since they were put in commission seven years ago. The more experience a person has with the actual behavior of piles under heavy loads the further away he is apt to stray from any set of established formulas. Seventeen years ago, the action of an extraordinary load on the pier near the foot of West Twenty-sixth Street received some study, when an area 20 by 50 ft. loaded with 1 200 lb. per sq. ft., and another area 10 ft. wide and 75 ft. long was loaded with nearly 1 300 lb. per sq. ft.; after making all allowance for weight of pile, dead load and distribution of live load, it was found that the actual load carried by the piles involved was in the neighborhood of 35 tons, developing an actual surface resistance obtained from the average of 14 piles of 767 lb. per sq. ft. against a minimum of 700 and a maximum of 839, with about 40 ft. of pile in the mud. Some years ago T. C. Clarke announced that the piles in the foundations of the Hawkesbury Bridge developed a surface frictional resistance of about 500 lb. per sq. ft. It is the writer's firm conviction that piles driven in a soft mud may be loaded to a point that will often rupture the supporting bottom before starting the pile.

It may sometimes happen that the bottom may be of such a nature that it would not be safe to stop driving when the limit for an 80-ft. pile is reached. If the indications are that rock or other hard, resisting bottom can be reached with a pile spliced to 100 ft. or so, then splicing is likely to be more effective and cheaper than lagging. The splice at present used by the Dock Department consists of six pieces of 5 by 5 in. spruce or yellow pine, each 14 ft. long, used as three pairs of fish-plates, the two ends of the pile being dressed at the butt joint to a hexagon with 5-in. faces. Opposite fish-plates are fastened together with three ¾-in. screw bolts on each side of the joint, with three ½ by 9-in. dock spikes in each fish-plate on both sides of the joint. The two ends are also doweled together with a 2-in. white oak dowel 12 in. long. The average pile tapers in diameter about 1 in. in 7 ft., therefore requiring for a pile spliced to 110 ft. one 60-ft. and one 80-ft. pile, the lower section to cut off not less than 14 in. at the joint with a point not less than

6 in., making the upper section a 17-in. butt cut off not less than 10 in. in diameter at the joint. Thus, it will be observed, that splicing is apt to be expensive and wasteful.

To overcome this, the Department has recently resorted to a device used elsewhere for increasing the surface friction of an 80-ft. pile, and therefore its supporting power by a system of lagging. If the conditions indicate that piles exceeding 80 ft. in length are required, they are lagged with two or four streaks of 5 by 6-in. spruce, each streak in two 15-ft. lengths, fastened to the pile in pairs with two 1-in. screw bolts and with two $\frac{5}{8}$ by 12-in. dock spikes in each piece on the lower portion of the pile, extending upwards to within 45 ft. of the sawed-off butt to insure full mud immersion.

The efficiency of this method of lagging was determined from a set of experimental tests made by the Department about two years ago, the results of which seem to show that in a deep mud formation like that on the Chelsea Section, piles thus reinforced may be relied upon to safely support 20 tons. Time and space prevent a more detailed discussion of this subject at the present time.

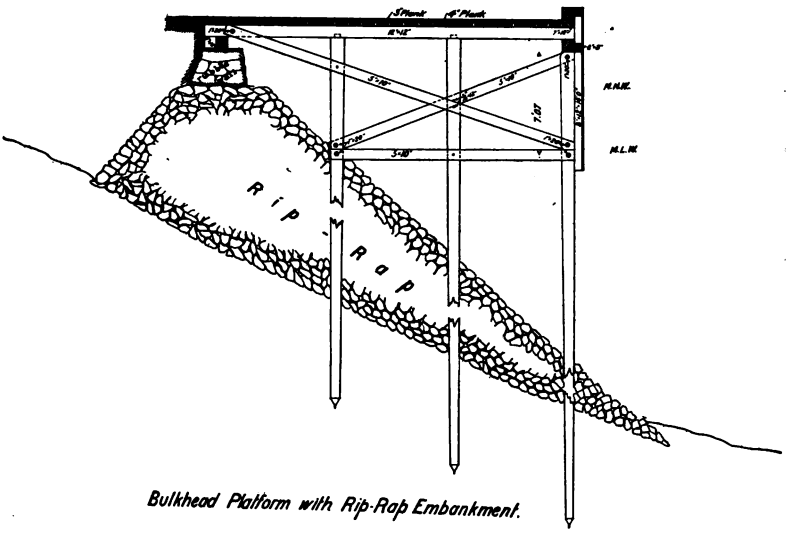
Up to 100 ft., splicing will add about $17 to the cost of the pile driven and stay-lathed; and lagging (piles 80 ft. long) will add about $12 to its cost, driven and stay-lathed.

Timber Bulkheads.—The bulkhead is the retaining structure which forms the limitation of solid filling and may be temporary or permanent. Temporary bulkheads may be economically built of riprap, sheet piling or cribwork. The permanent bulkhead or sea wall is invariably some form of masonry.

If of riprap, it usually consists of an embankment carried up to about half tide, topped off with a light rubble stone wall with a timber platform on piles of any required width in front, the piles being driven through the riprap slope. (See Plate XXXIII, Fig. 1.)

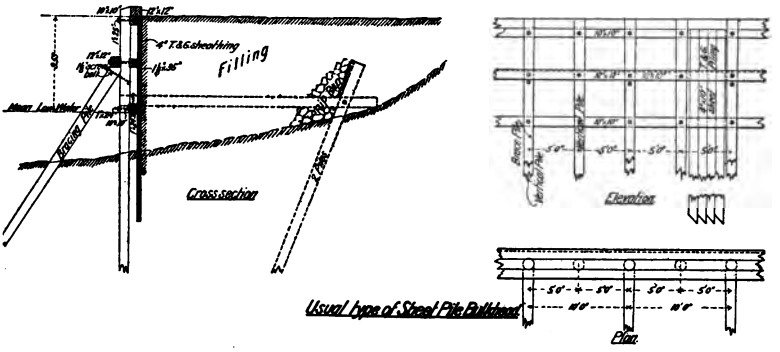
Where a good penetration is possible there are several kinds of sheet-pile bulkhead well adapted for economically retaining shallow filling, consisting of a front row of piles, capped and waled on the inshore side with yellow pine at mean low water, at mean high water and at the top, for the support of the vertical plank sheathing. The capping of the front row of piles forms a backing log. The spacing of piles and sizes of timber all depend upon the height

PLATE XXXIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



Bulkhead Platform with Rip-Rap Embankment.

FIG. 1.



Usual type of Sheet Pile Bulkhead

FIG. 2.

of the filling. This type of bulkhead may be braced in front with inclined piles (see Plate XXXIII, Fig. 2), where wharfage is no object, or it may be tied back in the rear to a set of anchor piles. The filling in the rear of these bulkheads may be planked over or paved. They cost in the neighborhood of about $6 per running foot.

Of all the structures with which the Department has had to deal, the most uncertain and unsatisfactory are crib bulkheads. No one can afford to predict their behavior; they may bulge on the face; they may retain a constant profile but bulge for line; they may even show an inshore movement at times; they may settle and they may not. Crib bulkheads are built of round logs, longitudinally and transversely, forming cells 8 ft. long lengthwise of the structure and about 5 ft. wide transversely. A sufficient number of cells are floored over just above the probable limit of settlement and filled with riprap for sinking the structure to place, after which all the cells are likewise filled. Above mean low water the wharfage face is usually finished off with square 10 or 12-in. yellow pine with half-round fenders. No longitudinal log should be less than 6 in. at the small end nor less than 50 ft. long, as a rule. Transverse logs below mean low water should not be less than 8 in., and above mean low water not less than 10 in. in diameter, and should be in single lengths from front to rear. The fastenings below mean low water should never be less than $\frac{3}{4}$-in., and above mean low water not less than $\frac{7}{8}$-in., dock spikes. For wharfage purposes, the front profile should have a batter of about $1\frac{3}{4}$ in. in 12. The back may be vertical or inclined, with a step of from 6 to 12 ft. or more in width at mean low water (see Plate XXXIV, Fig. 1).

The usual crib construction requires a top width of not less than 16 ft. for a depth not exceeding 10 ft. below mean low water and from 18 to 25 ft. and upwards, increasing at mean low water to 30 or 40 ft., if necessary for greater depths. The bottom width or distance between centers of front and rear longitudinal logs should never be less than the over-all height in order to secure the necessary weight for stability. For great depths, say, from 30 to 40 ft., a crib will require a reinforcement in the nature of anchor cribs in the rear, which are in effect a widening of the crib transversely below mean low water. A crib bulkhead should never be founded

upon any other than hard bottom, all soft material being removed by dredging. In almost any bottom other than rock or hardpan a crib will settle more or less, but where a level bottom of hard material can be obtained there is no reason why, with ordinary care in filling in behind, a crib of this character should not hold its position and line fairly well. But the dredging does not always leave a level bottom or a bottom of uniform consistency, and before the filling in the rear has progressed very far, which should always be deposited from the crib inshore to drive any possible mud wave away from the structure, it is apt to show signs of movement. In the case of a very hard or rock bottom the bottom logs of the crib must be laid out to fit the surface upon which it is to rest as developed by contours. An extreme case of this kind was built about four years ago at the foot of East Eightieth Street. The rock sloped outshore in several places more than 30° and was very irregular, longitudinally, necessitating the laying out of almost every course of logs up to mean low water. The logs were cut to lengths indicated on diagrams furnished the contractor, the crib was built accordingly, floated into position, anchored, loaded and sunk, and as described by the engineer in charge of the work, it "took its position like melted cheese." The reason why this crib has not budged is probably because it was anchored to 2½-in. pins bedded into the rock in the rear with 1¼-in. chain.

In a crib with a level bottom designed as hereinbefore described the resultant thrust at the base of the crib will be found to intersect the base at a point fairly close to the middle third, if not through it. If, however, the bottom is sloping and the cribwork is built so as to conform with the bottom, this resultant will pass close to the toe, depending upon the depth of the latter below the heel of the crib. The maximum compression, therefore, is at or near the toe in the very weakest portion of the structure, the triangular section below the heel. Owing to the cellular construction, the multiplicity of joints and looseness of cell filling, the crib bulges at the weakest portion, and in readjusting itself assumes a front profile outshore of its original position; the point of maximum bulging being so far below mean low water the impression created by external appearances is that the crib has slid outwards. This bulge can be avoided by depositing a bank of riprap at the toe, extending to a height on a level with the heel, with a broad berm in front, or

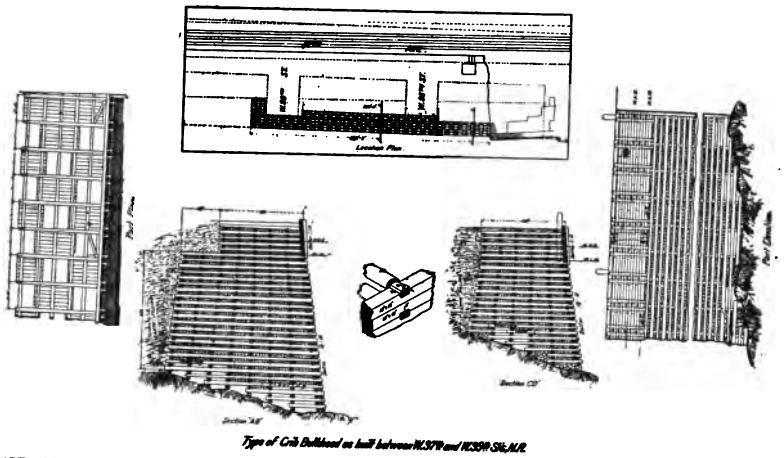


FIG. 1.

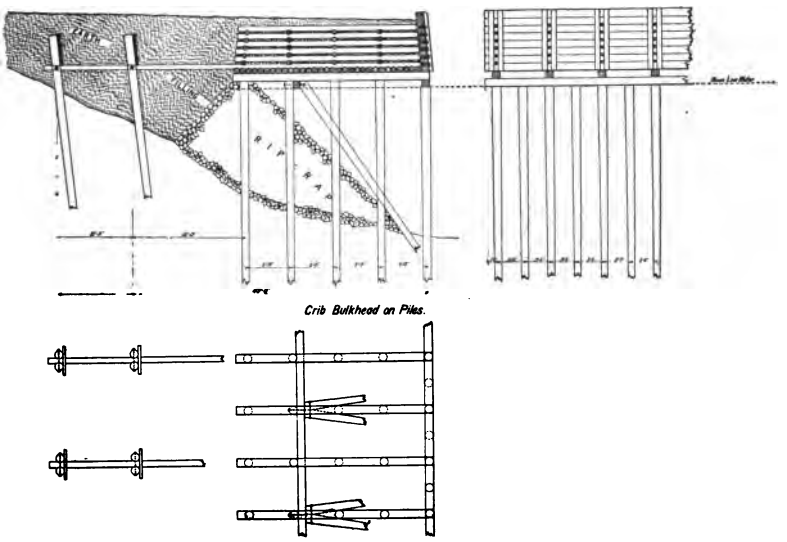


FIG. 2.– CRIB BULKHEAD ON PILES.

by omitting that portion of the cribwork below the heel, and founding the crib with a level bottom upon a bed of riprap having a broad berm in front.

From the very nature of cribwork it is impracticable to introduce any system of bracing, for weight is the desideratum, and any attempt to modify the rectangular shape of the cells would act as a barrier or obstruction against their being completely filled.

The Department has built up to the present time about 17 550 lin. ft. of crib bulkhead.

A departure from the solid construction is often met with where cribs are supported upon piles (see Plate XXXIV, Fig. 2, with inclined piles omitted). This type is no longer used in the Department and is not to be recommended. The excuse for its existence is the saving in dredging. Piles are arranged in rows on 6-ft. centers between rows, cut off at mean low water, capped, close floored with round logs, and the structure finished up to grade with cribwork; alternate transverse rows of piles are braced with an inclined pile. The rear row of piles lies in the center of a riprap embankment and retains the filing.

The writer believes that this form of bulkhead may be made efficient by the use of two bracing piles, either in tandem or in pairs, and by tying the structure back with some of the bottom cross logs to properly sheathed anchor piles, as shown in Plate XXXIV, Fig. 2.

The Bulkhead Wall or Sea Wall.—The most expensive and most important class of Department work is the bulkhead wall. This leads the way in all permanent improvement. After a section of the wall is built the area in the rear is filled in, graded and paved, and the completion of the piers which spring from that section of the wall usually marks the completion of the section. The progress of the bulkhead wall may be said to keep pace with the acquisition of property, at least along those portions of the water front sufficiently important to warrant the expense of permanent improvement. In this way, the acquisition of a piece of water-front property or several adjacent parcels marks the commencement of work at that locality, as a section of improvement under the name of some local designation, as, for instance, the Chelsea Section, the Yorkville Section, the Old Slip Section, the Cedar Street Section, and so on, comprising up to the present time eighty-one different sections of work. Therefore, when the term section is used in this

paper under the name of a locality, it simply designates location and not type of construction. For it can readily be conceived that the character of foundation may so vary in a long section as to involve two or more different types of wall.

In beginning the work of improvement on one of these sections, the first step is the preparation of the bottom for the foundation of the wall by the removal of all structures from within the area of the marginal street or by demolition, stripping, excavation and dredging the bulkhead wall area as well as the areas of the future slips.

Generally speaking, four types of bulkhead wall prevail in the Department, depending upon the character of bottom encountered as developed by borings and test piles, with modifications suggested by experience or by unusual local conditions. These types may be enumerated as the shallow rock section, the deeper rock section, the hard or firm bottom section, and the soft bottom or deep mud section.

Before describing the different types of wall, it may be as well to point out the features in the construction common to all types (see Plate XXXV). With few exceptions the upper portion of a wall rests upon a heavy concrete block with a front parapet about 2.45 ft. below mean low water made to receive the bottom course of the granite facing, which extends from this elevation with a front batter of 1 in 12 up to the surface grade (+ 9.38, as a rule). The granite facing is in four courses surmounted with a coping 2½ ft. thick, about 3 ft. wide and in length 8 ft. The bottom course is about 4 ft. high. The three remaining courses about 1 ft. 9 in., each course laid with alternate headers and stretchers, the headers being cut dovetailed in the back to bond in with the mass concrete backing which extends from the top of the concrete block to the under side of the coping and back from the face from 5 to 8 ft. The face and back of the granite are quarry-faced, with ends and beds pointed off, the tops being 5-cut, hammer-dressed for a width of 3 in. from the face. The ends of all stones are cut dovetailed with a slope of 1 in 12; the coping is pean hammered on top with ends and bottom cut smooth for a width of 5 in. A 12 by 12-in. backing log is fastened to the coping with expansion bolts. The backing log may or may not be provided with cleats.

An embankment of riprap is deposited in the rear, carried up to

PLATE XXXV.
THE MUNICIPAL ENGINEERS
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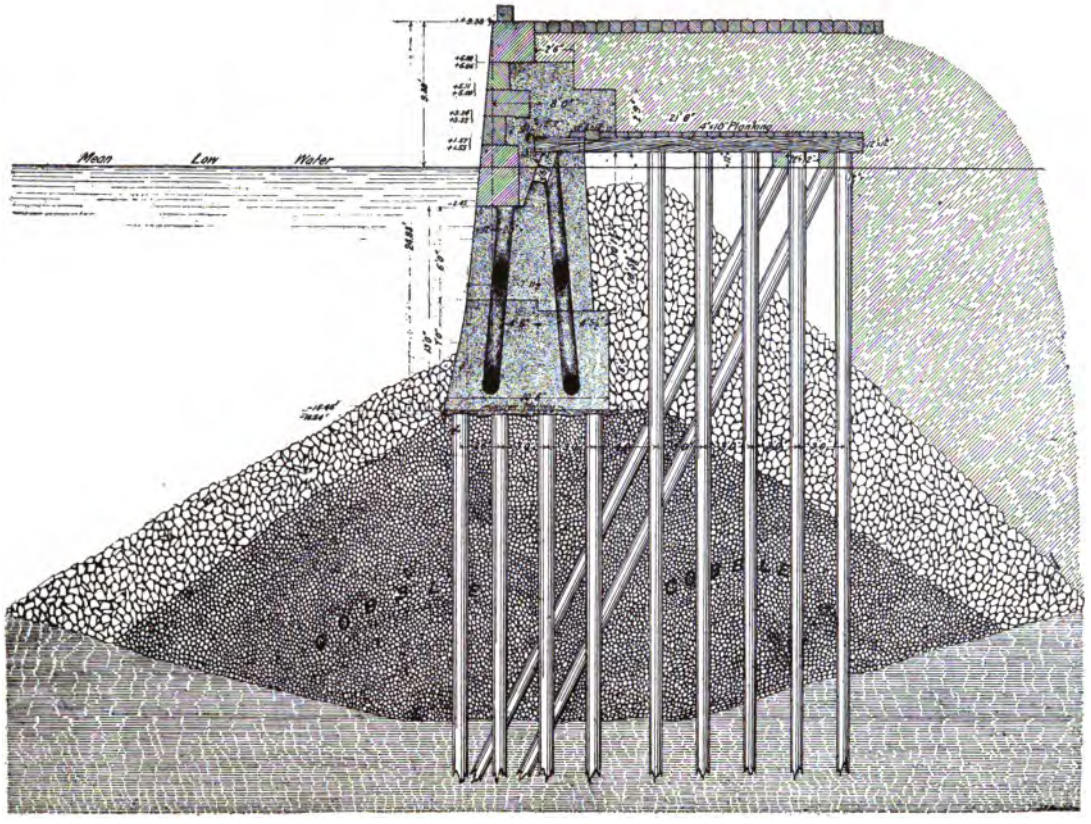
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



Foundation and platform piles spaced 4 ft. centres longitudinally except at front row 2 ft. 6 in.

MODIFIED WALL OF 1899.

PLATE XXXVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

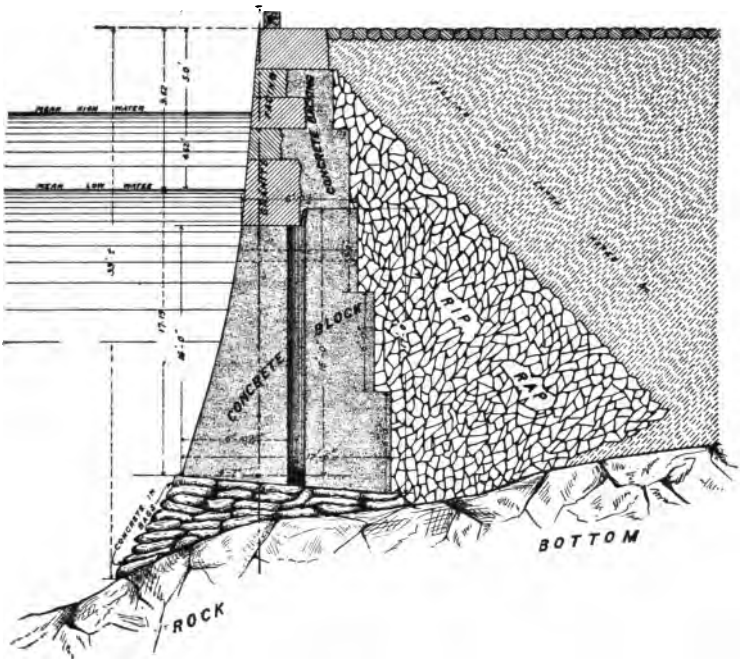


FIG. 1.—WEST 52D STREET SECTION, SOUTH END.

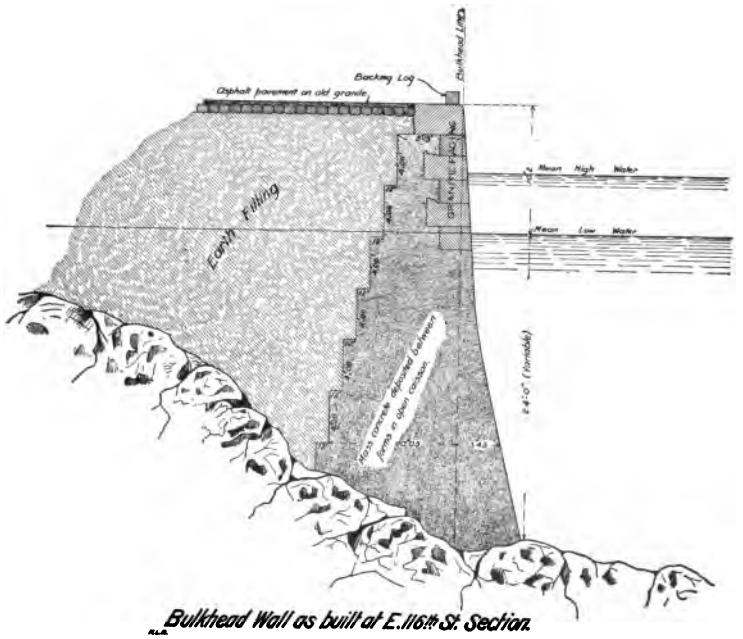

Backing Log
Asphalt pavement on old granite
Earth Filling
Mean High Water
Mean Low Water
Bulkhead Wall as built at E. 116th St. Section.

FIG. 2.

high water or to nearly the coping grade, with a top width of 5 or 6 ft. An embankment of riprap is also usually deposited in front of the wall, the slope of which intersects the face of the latter at about —13.

The concrete blocks are all moulded in air at one of the two Department yards and allowed to stand from 10 to 14 days before shipping to the work. The concrete is a 1:2:5 mixture; the mould boxes are cored for chain grooves and chain holes. In the work these grooves match in adjacent blocks and are packed with concrete in bags. Although the blocks vary in size and weight, the tops of the main base blocks are very similar. The portion in the rear of the parapet is moulded in such a way as to form with adjacent blocks a series of salient and depressed dovetails with which the concrete backing forms a complete bond (see Plate XLI, Fig. 1). These blocks vary in weight from 35 to 80 tons. There is a great lack of uniformity in the weights of sub-blocks, ranging as they do from 34 to 95 tons, and from 6 to 18 ft. in length on the face.

Resuming now the discussion of the different types of wall, let us take up, first,

The Shallow Rock Section.—Where rock is found at a depth of about 25 ft. or less the wall area is dredged off thoroughly, and with the aid of a diver the rock surface, holes and pockets are pumped off clean with an 8-in. pump capable of passing bricks and small stones. The foundation is then prepared by laying up concrete in bags about 3 ft. long, 2 ft. wide and 8 in. thick to a formation level, having an inshore slope of 1 in 12, dressed off with a gravel concrete mortar by the aid of divers and heavy iron straight edges, worked back and forth, to receive the base blocks (see Plate XXXVI, Fig. 1). These blocks are usually about 17 ft. high, 6 ft. long on the face, with a base of about 12½ ft., a top width of 7 ft. and stepped off in the back. They weigh about 70 tons.

Plate XXXVI, Fig. 1, shows the wall as built at the West Fifty-second Street Section, south end.

A further modification shown in Plate XXXVI, Fig. 2, is at the East One Hundred and Sixteenth Street Section, which is a mass concrete wall built in an open caisson or coffer-dam on rock 25 ft. below mean low water. This is the only instance in the Department of this kind of construction. The wall has a bottom width of 15 ft.

Of the shallow rock type about 1 125 ft. have been built.

The Deeper Rock Section.—For depths of from 25 to 40 ft. to rock, covered with soft material, the latter is dredged and the foundation prepared in the same manner as before described; the wall differing mainly in having one or two sub-blocks from 5 to 9 ft. high, according to depth. The top block is 19 ft. high at the back with a bottom thickness of 14½ ft. and a top thickness of 8 ft. (see Plate XXXVII.

The principal modifications of this type are on the Broad Street Section with its rabbeted joint between sub and base blocks, and on the East Seventy-fourth Street Section (see Plate XXXVIII, Fig. 1), where the rock is unusually steep and shelving requiring special sub-blocks every few feet, the cavities in the rear between these sub-blocks and the rock being filled with mass concrete as the blocks are set.

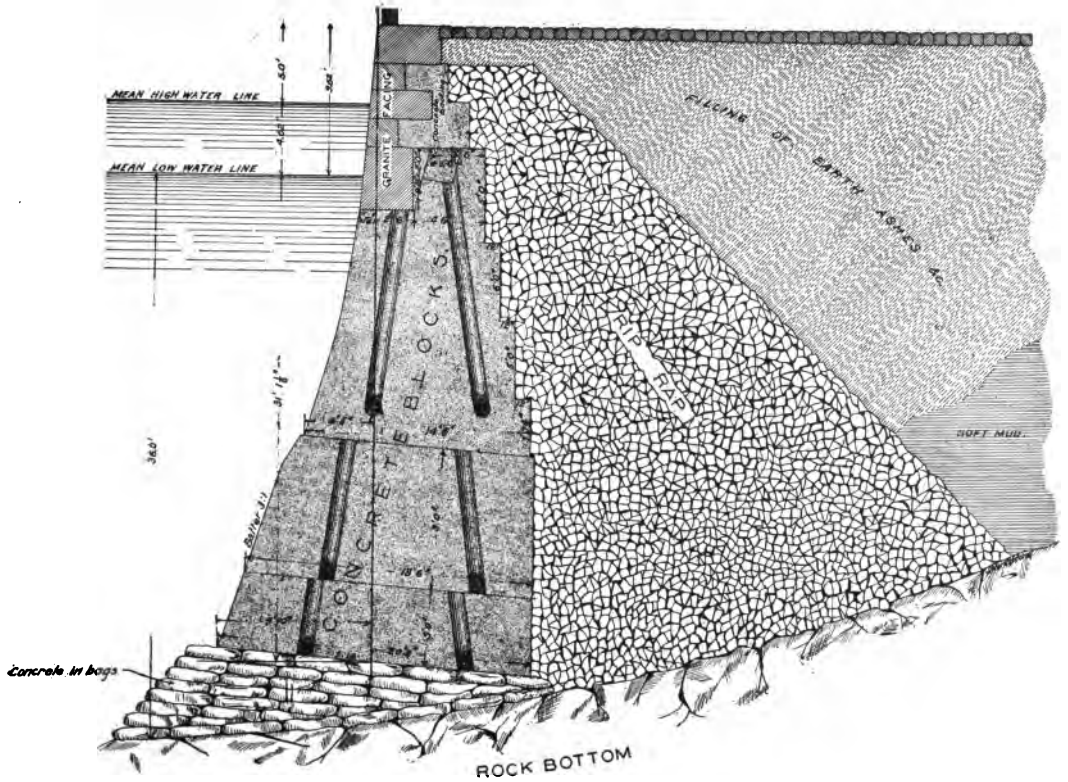
The Cedar Street Section (Plate XLVIII) is the most recent modification of this type and is now under construction. Rock is about 40 ft. below mean low water. In this wall the bottom course comprises a front and rear sub-block 18 ft. long on the face, with broken stone filling between. The two upper blocks are 6 ft. long. The bottom blocks are 95 and 88 tons, respectively.

In 1871 General McClellan began operations at the Battery and built the Battery Section (Plate XXXVIII, Fig. 2). The rock at about —46 was dredged off to firm bottom. A riprap embankment was deposited with a top width of about 26 ft., topped off at —20 with a bed of concrete and broken stone 2 ft. thick. From this grade the wall was continued up in fifteen 2-ft. courses of granite with a bottom width or base of 19½ ft. The following year he carried up his embankment to —14, and began the system of concrete block construction, substituting for the granite two courses of concrete blocks.

Up to the present time the Department has built about 2 643 ft. of the deep rock type of wall.

Hard or Firm Bottom Section.—When the bottom is of such a nature that piles will drive to refusal or to rock and be embedded in firm material for most of their length, requiring but little more dredging for the removal of any soft material than is necessary for cutting off foundation piles at the proper depth, the section similar to Plate XXXIX has been successfully used. This type is adapted for depths of from 50 ft. and upwards to rock, in a bottom sufficiently firm or compact to pre-

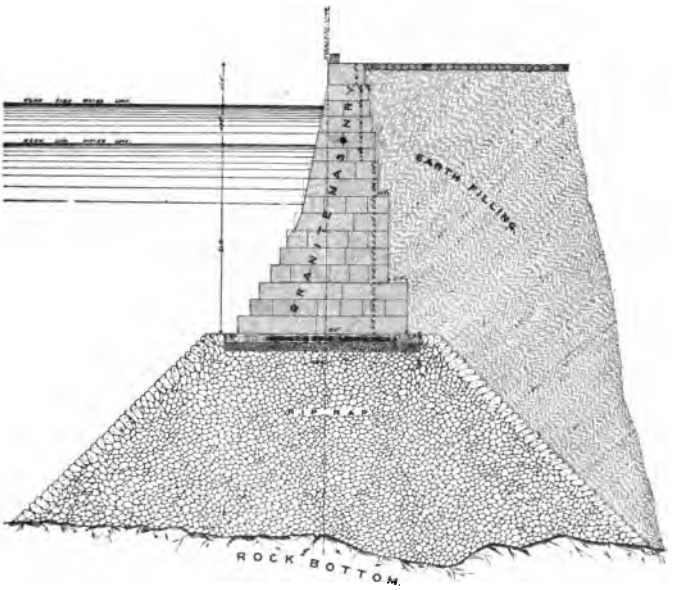
PLATE XXXVII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



West 52d St. Section North End,
"B"

Type of wall as built on the E. 74th St. Section.

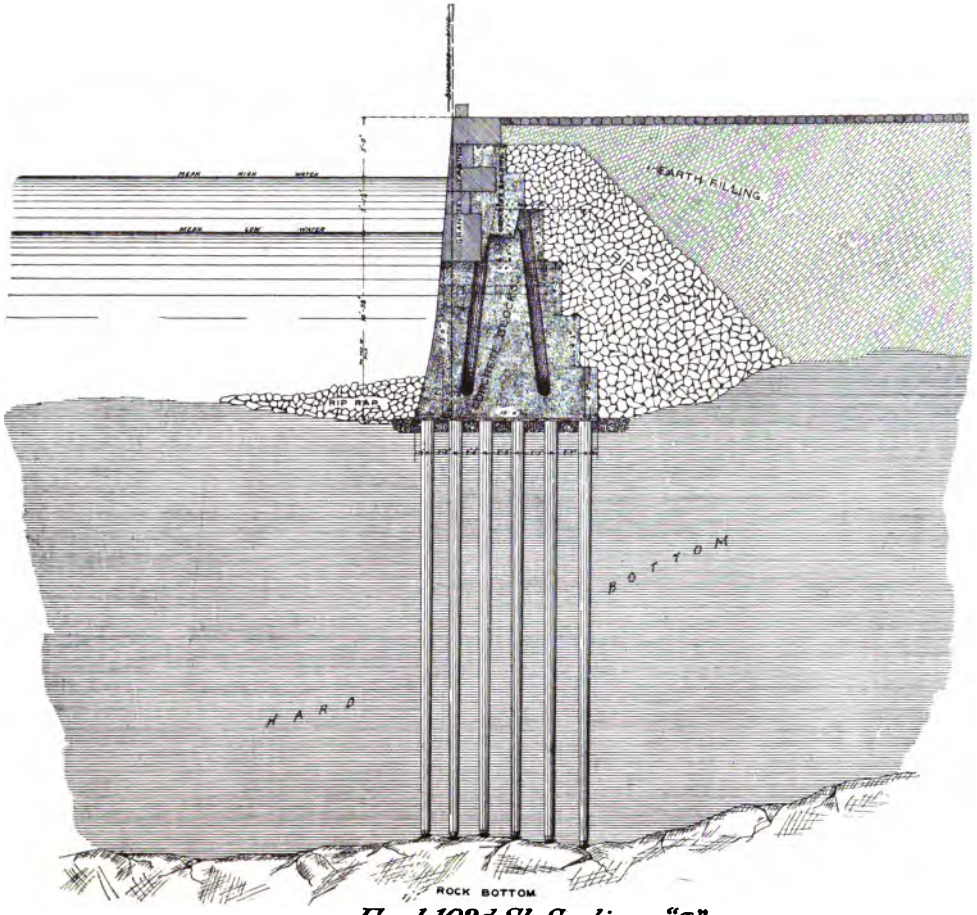
FIG. 1.



Battery Section, "A."

FIG. 2.

PLATE XXXIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



East 102d St. Section, "A."

PLATE XL.
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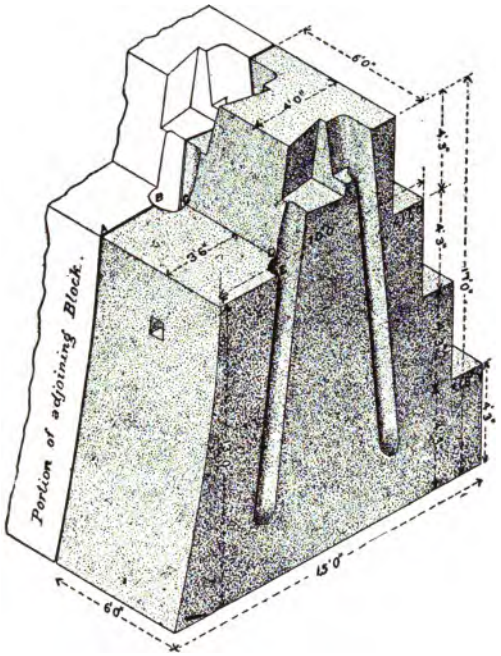
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

Line of Dock
Foundation piles in front row shown thus
Remaining foundation piles shown thus
Extra foundation piles added shown thus

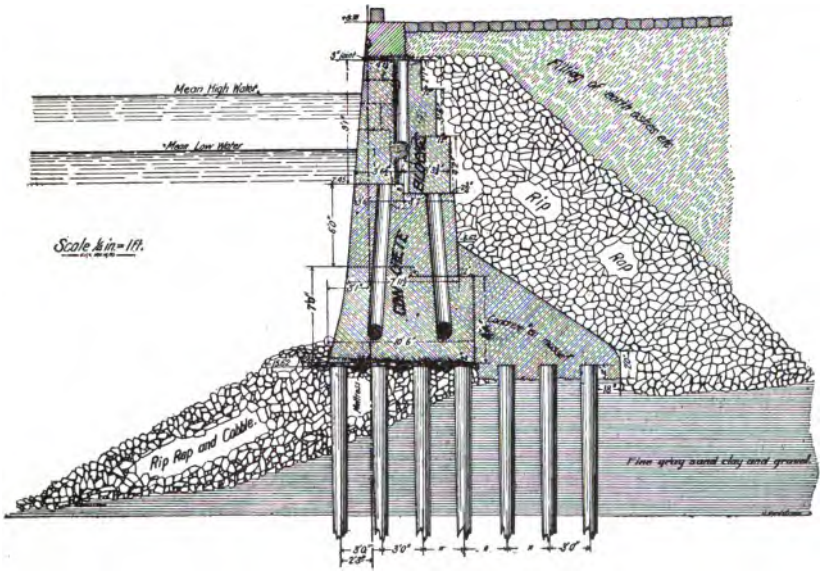
Diagram showing location of foundation piles, as cut off in the work and as determined by screening.

PLATE XLI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



ISOMETRIC PROJECTION
OF CONCRETE BLOCK.

FIG. 1.



East 23rd St. Section.

FIG. 2.

vent any forward movement of the piles either from the vertical or in mass. Dredging is carried to a depth of about 20 ft. The piles are cut off at about —15, and their location checked by a diver with the aid of a heavy wire screen. Extra piles are driven wherever the screen indicates insufficient bearing, for with the utmost care piles when cut off at this or greater depths will sometimes fall outside of the bearing area required (see Plate XL). The loose or soft mud between the piles and for about 20 ft. in front is pumped or washed down to hard material, and the space above filled up with cobble to the tops of the piles, or to the cut-off grade. Mattresses of mortar mixed 2½ to 3 are placed on top of the piles to insure a firm bearing for the base blocks, which are 6 ft. long on the face, 17 ft. high at the back, 10 ft. wide on top, 15 ft. wide on the base and weigh 77 tons. Riprap is deposited in front and rear. This type was first used on the East 102nd Street section in 1891, these blocks being the first moulded with the dovetailed tops (see Plate XLI, Fig. 1).

A modification of this type appears in the East Twenty-third Street section (Plate XLI, Fig. 2). Here, the piles are cut off at —15.62. The filling between the piles and in front of the wall is riprap and cobble deposited upon hard material. Two blocks, with a rabbeted joint between, are used, making together a top width of 7 ft., a bottom width of 10½ ft., a total height of 16½ ft. and a face length of 8 ft. The bottom and the top blocks weigh respectively 34 and 38 tons. In the wake of the ferry structures on this section, where the exposed face is concealed, the top of the wall is formed of a third block. The two lower blocks were designed for an entirely different type of wall to permit handling by the 40-ton derrick at a time when the 100-ton derrick was undergoing repairs. They were made available in this type, however, by the use of a relieving bed of concrete deposited in the rear around the heads of three longitudinal rows of piles for a width of about 10 ft., and carried up with a slope to the back of the blocks about 9 ft. above the tops of the piles.

Of the firm or hard-bottom type about 3 784 feet of wall have been built.

Soft Bottom or Deep-Mud Bottom Section.—The extreme condition that prevails in this type of wall is a mud bottom, increasing in density with depth, overlying rock, at a depth

of about 170 ft. below mean low water, as on the West Twenty-third Street section, south end. The minimum depth of rock for this type is about 40 ft., as on the East Ninety-first, the Dey Street and the West Fifty-seventh Street sections. The Department construction thus far has involved all kinds of depths of mud between these two.

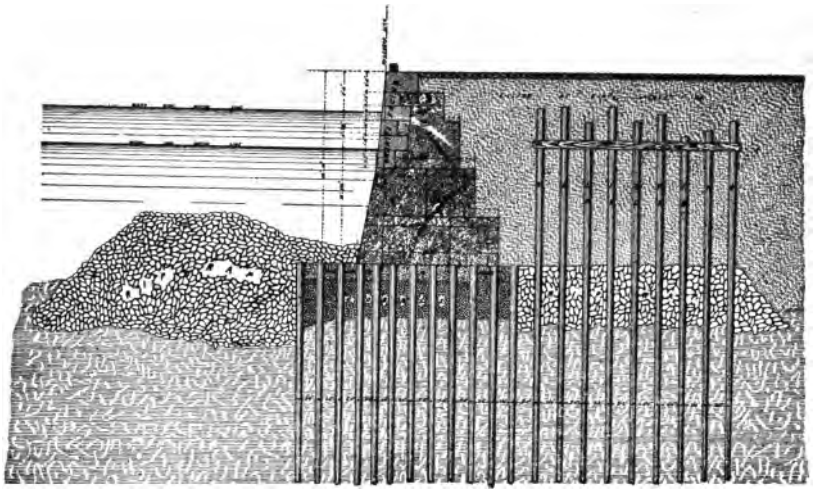
In 1873, General Graham began the construction of the Christopher Street section, using the method shown in Plate XLII, Fig. 1. This wall showed evidences of weakness after several hundred feet were completed and filling in the rear was begun, but the outward movement was checked by depositing a heavy embankment of riprap in front of the wall. The principal feature of this wall was a bed of concrete about 2 ft. thick at the tops of the piles, which it was supposed would stiffen the foundation materially in a horizontal direction; but the mass was not only broken up by the large number of piles, but the concrete itself was badly washed out leaving practically a 2-ft. thickness of small stone filling, where a strong mass of concrete was expected. The relieving piles in the rear were driven, subsequently, at the recommendation of a Board of Consulting Engineers.

The Morton Street section (Plate XLII, Fig. 2) is a later modification of General Graham's wall made by his successor, George S. Greene, Jr., in 1875, consisting principally in the introduction of a grillage braced underneath with inclined piles. The grillage consisted of two courses of 4-in. spruce plank, laid at right angles with each other, fastened together with ¾-in. treenails, and fastened to each pile with a 3-in. oak treenail driven 12 in. into the tops of the piles.

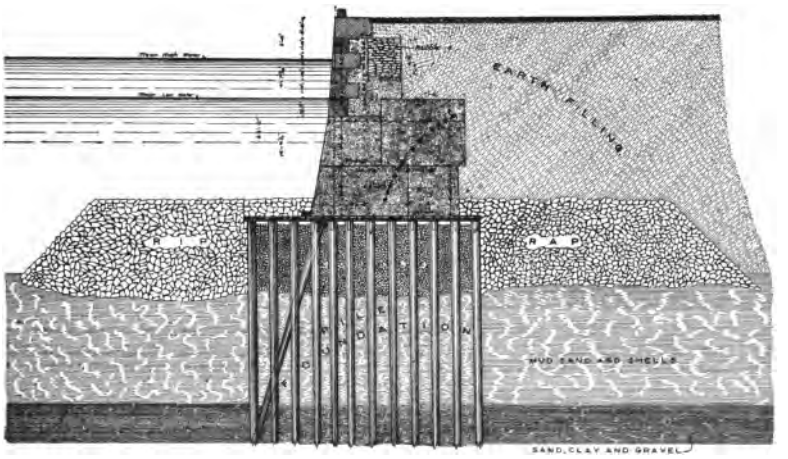
Plate XLIII, Fig. 1, shows the construction as originally designed for a portion of the Canal Street section by General Graham but modified by George S. Greene, Jr., by the introduction of the relieving platform in the rear. The top and bottom blocks are laid as headers and stretchers respectively.

Plate XLIII, Fig. 2, shows the construction designed by General Graham for a later portion of the Canal Street section, and to which he pinned his faith with enthusiasm. This was intended to be the prevailing construction for deep, soft bottom. The piles were punched down to an average distance of about 13 ft. below mean low water with a heavy oak follower 12 in. square and 26 ft. long,

PLATE XLII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

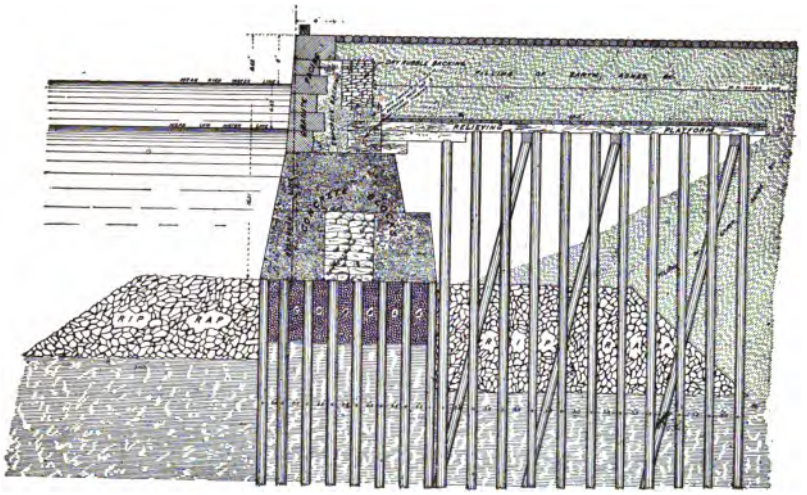


Christopher St. Section.
A.
FIG. 1.

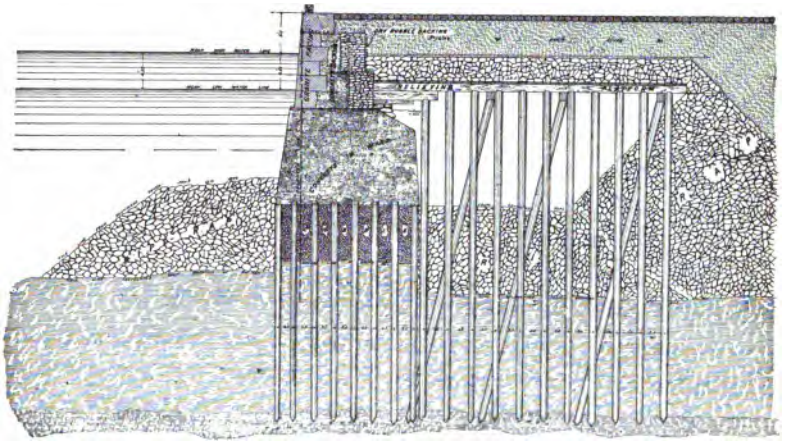


Morton St. Section.
Christopher St. Section.
B.
FIG. 2.

PLATE XLIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



Canal St. Section.
C.
FIG. 1.



Canal St. Section,
A.
FIG. 2.

armed at the bottom with an iron thimble and banded with iron to strengthen against fracture. This uneven punching was intended to provide a good grasp to the concrete around the pile heads.

From the tops of the piles up, the construction is a mass concrete wall with granite facing above mean low water. The concrete was deposited in uncovered buckets in a wet caisson. General Graham resigned in 1875 and shortly afterwards the Commissioners received from outside sources adverse criticism of that portion of the wall built under this type. The Board, therefore, ordered George S. Greene, Jr., General Graham's successor, to make an examination of the wall and report its condition. An examination of the face of the wall was accordingly made, chiefly with the aid of divers. The latter reported the lower portion of the mass concrete construction to have fallen away at the toe, entirely exposing the front row of piles, with very little bearing upon the second row. The bottom of the mass was found to consist chiefly of the broken stone portion of the concrete, the cement having been washed away in the operation of depositing the concrete. In the report of the Engineer-in-Chief, he protested against the further continuance of this form of construction until after the advisability of proceeding might be determined by a board of expert engineers. Consequently, at the solicitation of the Commissioners, the Mayor appointed General Newton, General Gilmore and Wm. E. Worthen, a Commission to examine into this subject and report their findings with recommendations. The investigations of this Commission were of an exhaustive nature, combining a series of examinations along the entire face of the wall with the aid of two sets of divers, one set being used as a check upon the other, an examination made by sinking shafts through the interior of the mass down to the pileheads, and experimental observations wherein a large box was constructed with pile butts arranged on the bottom in the same manner as in the wall, the box being sunk and filled with concrete and deposited in the same manner as was done in building the wall. The result of these investigations confirmed those made by the Engineer-in-Chief, and showed large cavities existing around the pileheads in places, and the bottom of the mass consisted chiefly of the loose broken stone of the concrete covered with laitence in places, which, when taken out and thrown into the water, floated away. The experimental box, when raised from the water where it had been im-

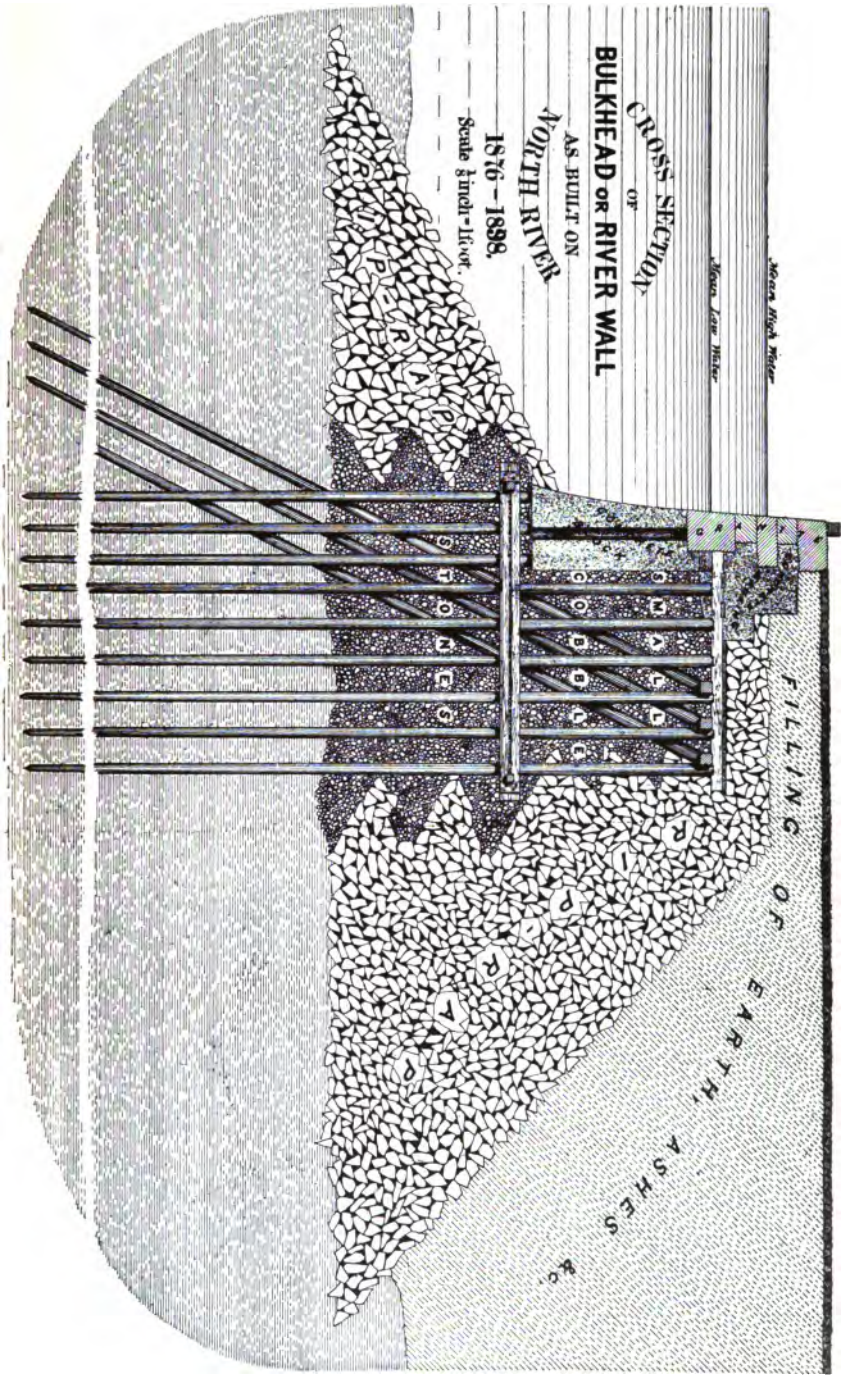
mersed for several weeks, showed that beyond question the defects reported by the divers actually existed in the work.

The Board reported against the continuance of this method of construction and recommended the building of a platform in the rear of the wall of sufficient width to take the entire weight of the back filling and surcharge to relieve the wall from thrust and possible destruction; for it must be borne in mind that at the theoretical point of rotation there was no fulcrum or toe that could be relied upon. Quoting from the concluding remarks in their report, they say:

"We cannot condemn a *system* of which many successful examples are reported, with which we are conversant, nor under certain circumstances and necessities should we hesitate to adopt it; but these do not obtain in the construction of these bulkheads; and we should recommend that all exterior faces here should be constructed in blocks and deposited on the pile foundations."

This led the Engineer-in-Chief to design an entirely new section, which is shown in Plate XLIV. The fundamental principle of this type of wall is the impossibility of overturning an embankment of riprap. It may settle or it may move outshore, but it cannot overturn. It will be noticed that virtually we have in Plate XLIV an embankment of riprap with a hearting of piles to carry a wharfage face of concrete blocks and granite. The most important feature of this wall is the relieving platform in the rear, braced with inclined piles to take the thrust from the rear filling and surcharge entirely away from the wall proper, and transmit it vertically to the mud or other bottom. By this device the concrete block which forms part of the wharfage face may be made very narrow fore and aft, as the only thrust on this portion of the wall is that which is transmitted by the riprap filling *under* the relieving platform, and this thrust, owing to the frequency of piles in the relieving platform can never amount to the thrust from an embankment of the same dimensions not broken up by these piles. Thus, the saving in concrete with its attendant expense in the labor of placing it is very considerable. The concrete block used in this type is 7 ft. thick on the base and 12 ft. long longitudinally, weighing in the neighborhood of 70 tons. Less than three rows of piles would not be permissible for stable construction, and the block is as narrow as this requirement will permit. But even so, in order to avoid the danger

PLATE XLIV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



of any of these piles, especially those in the front row, from working out from under the blocks, the binding frame, shown in the figure, will hold these foundation piles in position relatively with the relieving platform piles, and becomes a very important and indispensable feature of this type of wall. These frames are wedged against the outer piles, front and rear, by a diver. The essential details in the construction of this wall are clearly shown in the figure.

The behavior of this wall has been remarkable. It has been built along those portions of the North River waterfront where the mud formation is deepest, and where it was impossible for unspliced piles to bring up in driving. No spliced piles have ever been used in the bulkhead wall construction. The rock bottom in the deepest section of this type of wall is in the neighborhood of 170 ft. below mean low water, namely, in the vicinity of West Twenty-third Street. As was anticipated, the settlement on this section has been very considerable. The construction of the wall as far north as West Thirty-third Street extended over a period of fifteen years and was built in lengths of several hundred feet at a time, the question of property rights involving injunctions restraining the Department from making a continuous piece of work. At intervals of from 35 tc 75 ft. a vertical joint is provided, extending from the tops of the foundation piles between binding frames up through the coping, the function of these vertical joints being to enable a section of the wall to settle without serious damage to the concrete blocks or to the granite facing, and this is exactly what has happened. Periodical examinations of the wall as it progressed during its construction were made for level and alignment, and the oldest portion of this wall shows, in the vicinity of the West Twenty-fourth Street Pier, a settlement of about 3.6 ft. in fifteen years. The rate of settlement has not, by any means, been uniform. During the first two and a half years it was 2.4 ft.; during the next three years it was 0.6 of a foot, after which time, for about ten years, the settlement seems to have become uniform and at the rate of about ¾ of an inch per year. That portion of the wall most recently built between West Twenty-third and West Twenty-fourth streets shows a maximum settlement of about 3.45 feet during the period of observation extending from November, 1893, to June, 1895, nineteen

months; the settlement was uniform throughout this period, and had become about 4 ft. when the last levels were taken three or four years ago. This seems to show that the mud bottom underlying the wall foundation compresses rapidly, owing to the weight of the wall and the filling in the rear, and then gradually becomes sufficiently compacted to support the wall and the filling without much further settlement.

This type of wall seems to be unquestionably adapted to mud flotation. The effect of this excessive settlement, so far as the granite facing is concerned, has been overcome by omitting or removing the coping, which was laid temporarily, and adding courses of granite from time to time to bring the wall up to grade, one or two extra courses being required at different locations; and it has been found that immediately after the addition of extra granite with its backing of concrete the rate of settlement was increased during the first year or two.

This settlement of the bulkhead wall on the deep-mud sections is accompanied with a corresponding settlement of the entire mass of mud in its immediate vicinity, extending in the neighborhood of 100 ft. outshore of the wall and carries down with it the inshore ends of the piers, which spring from the wall in this locality. The effect on the piers is overcome by a system of double capping, separated with temporary chocks, which permit the blocking or wedging up of the superstructure from time to time upon the lower cross caps.

The deviation of the wall from its original alignment reaches a maximum of about 0.5 of a foot between West Twenty-third and West Twenty-fourth Streets, covering a period of about eight months. In places there has been an inshore movement of the wall of about 0.2 ft.

As confirming the theory of mud flotation, it may be stated that examinations made of the batter of the wall show practically no changes. Unquestionably, the wall, as a whole, is subjected to horizontal thrust from the filling in the extreme rear; and one of the remarkable features in its behavior is the fact that the resultant movement of the wall in the extreme case is represented by the diagonal of a rectangle 4 ft. high and 6 in. broad.

In 1895 a Board of Consulting Engineers, consisting of General

Lincoln Casey, George S. Morison and Wm. H. Burr was appointed by the Mayor at the request of the Commissioners of Docks to report upon the methods pursued in Dock Department construction, with a view to making recommendations for improving the wharfage facilities, etc. of New York City. Their comments on this type of wall may be of interest. The following is quoted from their report, dated February 6, 1896:

"To float a wall in mud when that wall must also take a horizontal thrust is a problem which can only be solved by care and experience, no formulas or mathematical rules being available. The wall, as now built, is a satisfactory solution of the problem. Your Board believes it to be a unique construction, one which is worthy of the most careful study, and deserves the strongest commendations. Its development has been gradual, and it is probable that future improvements will be made; but this Board does not hesitate to say that it considers this wall a solution of a very difficult problem, which is remarkable for its originality and the excellence of its results."

Up to 1898 the only modification made in this type of wall was the raising of the relieving platform 1 ft., in order to expedite the work and increase the speed of low water work.

After consolidation in 1899, the present Engineer-in-Chief, Mr. J. A. Bensel, made the first important modifications in this type of wall. The binding frame had always been a troublesome and expensive feature, and to meet Mr. Bensel's efforts to cheapen the construction of the wall without impairing its efficiency one of the longitudinal rows of platform piles was incorporated in the foundation, making four rows instead of three. The concrete blocks were redesigned with a base of 10½ ft. instead of 7 ft., and the binding frame was abandoned. At this time the 100-ton derrick, which had been doing continuous service for nearly thirty years, required overhauling and repairing. So, in order to avoid any delay in the setting of base blocks, the Department built a 40-ton derrick, and the blocks were designed of such a weight as might be handled with the new derrick. Thus, the wall, as modified by Mr. Bensel, and called the "modified wall of 1899" (Plate XXXV) shows two blocks with a rabbeted or offset horizontal joint between, the lower one weighing 34 tons and the upper one 38 tons. These blocks are, however, moulded as one for handling with the 100-ton derrick. Another

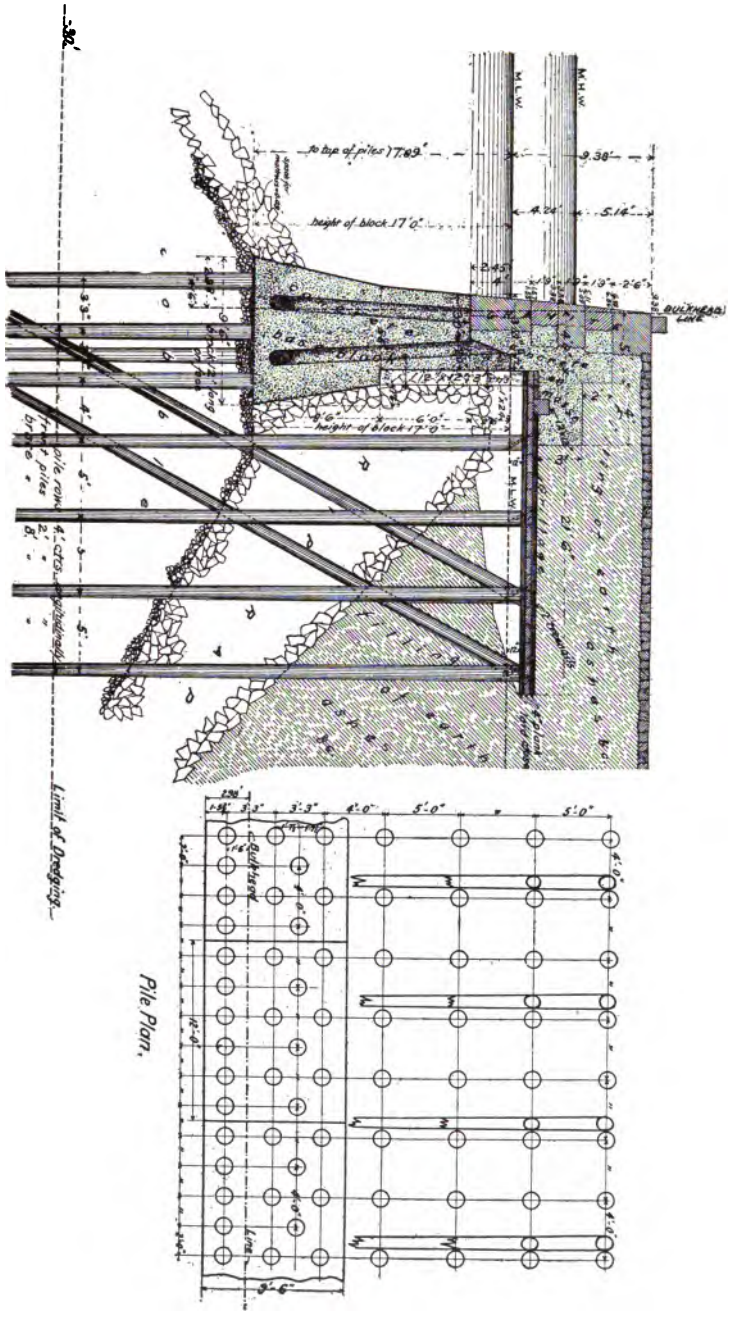
important modification consisting in reducing all of the granite about one-third in fore and aft dimensions, the granite serving as an ashlar to the concrete backing, which must be particularly heavy to resist the impact of vessels wharfing or mooring. The platform is 1 ft. higher than in the foregoing type or "wall of 1876," making it possible to prosecute the work with longer tidal intervals and with fewer delays from the infrequency of low water, which sometimes happens with exasperating monotony, and during which period, of course, no work can be done on the relieving platform, at the old grade.

This wall has been called upon to respond to demands upon it of a nature not anticipated in the earlier types. For instance, along South Street where the dredging for the wall has encroached upon what might be called the prism of influence underlying the crib bulkheads along this section, the danger of sudden movements in the latter has been a source of more or less anxiety, until the expedient of tying the wall back to special anchor piles was adopted. This tie consists of a 12 by 12-in. yellow pine stick notched down over the longitudinal key in the platform and extended back and framed in between a pair of braced anchor piles securely waled top and bottom, the waling being framed into the tie, the latter being extended several feet to provide ample resistance against shear with the fibre. This tie is positive, for the concrete backing in the rear of the granite facing, and, overlying the platform, bonds in with the longitudinal key in the latter, and transmits tension through the mass concrete backing to the concrete block itself. The frequency of these ties or the distance between centres depends as much upon judgment as upon anything else, for the dynamic effect of any movement, actual or anticipated, against which this expedient is introduced is utterly indeterminate.

Again, on the Chelsea section, where the entire region is made land or filled-in land extending about 1 000 ft. in the rear of the bulkhead line, it was expected that in dredging the area in front of the wall to 40 ft. for the accommodation of the deep draft vessels that are expected to occupy this waterfront, the removal of this prism of compacted filling might exert an influence upon the prism of the same kind of material in the rear released from this support and cause sudden movement of the latter.

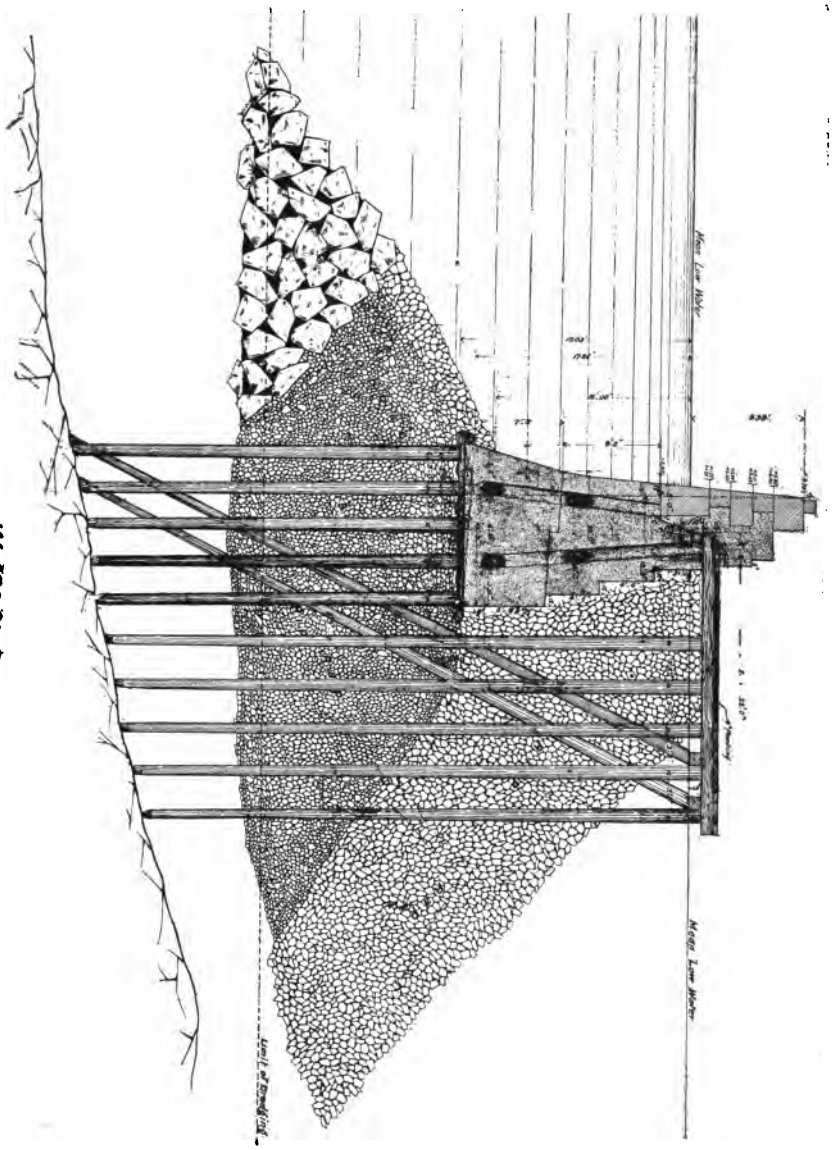
In carrying out the improvement on this section, rapidity of

PLATE XLV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



Chelsea Section.

PLATE XLVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



W. 42nd St. Section.

construction was made a dominant feature, and the "wall of 1899" was accordingly modified to meet the unusual physical conditions combined with speed in operations. The base block is a monolith 12 ft. long, 9½ ft. on the base, 15 ft. high and weighs 96 tons. It is supported upon a mattress, resting upon fifteen piles, driven in four rows, six in the front and three in each of the others, driven staggered, providing extra resistance at the heel against the opening of the joint at the toe between block and foundation piles. The latter are driven through an embankment of cobble deposited over the dredged area, with a depth of about 13 ft. The usual riprap embankment is deposited in front and rear. The pressure from surcharge and filling is transferred to the pile portion of the structure below the dredging line by a relieving platform, 26 ft. wide, built as a grillage of three courses of 4-in. plank, laid close, the middle course diagonal, supported upon three transverse rows of four piles each in the rear of every block. The grillage platform is braced with two inclined piles in every alternate row, driven in tandem, and is tied directly to the blocks by 2-in. tree-nailed fastenings to 12 by 12-in. yellow pine spuds supported upon the rear step and fastened to the backs of the blocks on 3-ft. centers with expansion bolts, in addition to the usual tie made by bonding the concrete backing on to the platform through the agency of a heavy 12 by 12-in. longitudinal key (see Plate XLV). It is expected that this wall will be cheaper and more rapid to build, and still afford the requisite resistance to unusual distortion from any movement in the old filling in the rear of the excavated area.

Another modification of this type of wall (soft bottom or deep-mud type) occurs at the West Forty-second Street Section (see Plate XLVI), where the piles bring up on rock at about —50 ft. with mud overlying it. The bottom was dredged to —35 ft. The foundation piles were cut off at —19. The wall proper is heavier, with a pile foundation of five rows, instead of four. The combined height of the concrete blocks is nearly 20 ft., with a bottom width of 13 ft. 3 in., and a top width of 7 ft. The riprap embankment in the rear is heavier and broader; the riprap in front is reinforced with a heavy embankment of derrick stone, and thus the inertia and stiffness of the entire wall has been increased against the possible outward movement of the underlying mud from the pressure of the filling in the rear.

The most recent modification of this type of wall is at the Rector Street Section (Plate XLVII), where we return to the single block 10½ ft. on the base, supported upon three rows of piles. The relieving platform is replaced with a mass concrete reinforcement in the rear of the base block to which it is locked by a dovetailed joint. Bracing piles in pairs take any thrust transmitted from the concrete reinforcement, making the wall very stiff at the base. The piles are short and act as columns. The material underlying the riprap is tenacious mud, sand and gravel, the dredging being carried to —30, deep enough to remove most of the softer material.

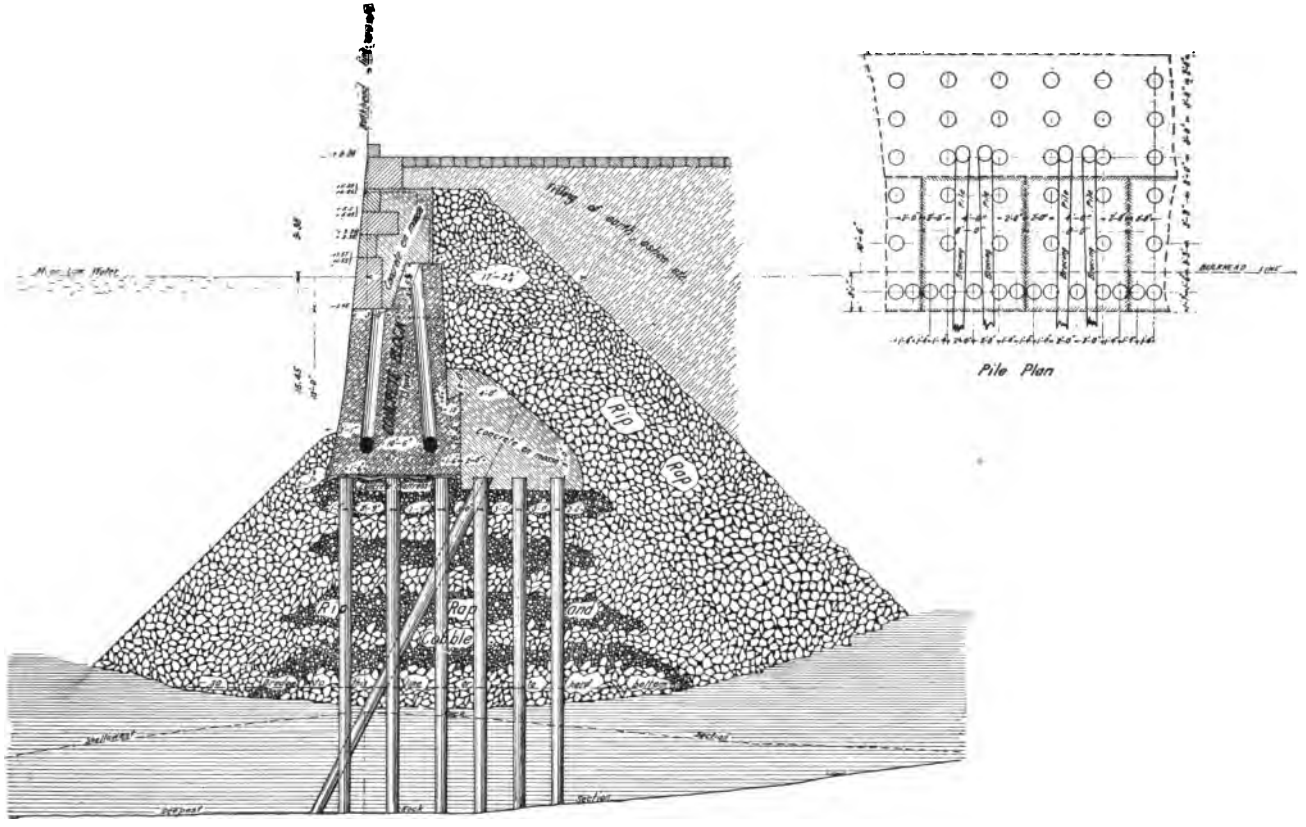
Thus, local conditions sometimes differ so much that some modification or other is suggested in many cases. This is particularly true of the lower East River water front of Manhattan below Corlears Hook.

Of the different types of cross-sections with their modifications, built upon a soft or deep mud bottom, there are 17 343 ft. of the earlier types built prior to the year 1899, and 5 680 ft. of the later types built since 1899.

Summarizing the foregoing, the length of sea wall built between 1871 and 1905 under the different types is as follows:

Shallow rock section (Plate XXXVI, Fig. 1),		
North River	571 ft.	
East River	554 "	
		1 125 ft.
Deep rock section (Plate XXXVII),		
North River	1 464 "	
East River	1 179 "	
		2 643 "
Hard or firm bottom section (Plate XXXIX),		
North River	...	
East River	3 784 "	
		3 784 "
Soft bottom or deep mud section, earlier types (Plates XLII, XLIII and XLIV),		
North River	14 089 "	
East River	2 669 "	
		16 758 "

PLATE XLVII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



Rector St. Section.

Soft bottom or deep mud section, later types Plates XXXV, XLV, XLVI and XLVII.

North River..... 3 254 ft.
East River..... 3 011 "

6 265 ft.

Making a grand total of.....30 575 "
Or 5.79 miles.

Behavior of the Sea Wall.—Of the wall thus far built, the average depth to rock for the different types, together with the observed average movement of the wall, vertical and horizontal, is as follows:

Type of Section.		Depth of Rock.			Settlement or Vertical Movement, in Inches.			Deviation from Line or Horizontal Movement, in Inches.		
		Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Shallow rock section	N. R.	30	30	30	0	1	½	0	1 shoreward.	
	E. R.	11	25	18	0	0	0	0	6 shoreward.	
Deep rock section	N. R.	30	45	40	0	1	½	⅜	⅜	shoreward ⅜
	E. R.	25	35	28	No observations.					
Hard or firm bottom	N. R.	None.	None.	None.						
	E. R.	30	113	71	¾	2	1⅜	1	7	4
Soft bottom or deep mud	N. R.	40	168	85	0	4	8	0	2.1	5½ and shoreward from 0.2 to 1.8
	E. R.	35	163	80	0	3	1¾	2½	5	4½

With reference to the above results it must be noted that no continuous or systematic observations of the movements of the wall have been made, excepting at such locations as indicated abnormal or unusual movement. At other locations, observations have been made at odd intervals; at still others, no observations at all have been made, but generally the amount of settlement has been detected when levels preliminary to laying pavement have been run over the coping. The results shown above, therefore, cannot be taken as representative, but are given more for the purpose of showing what may be expected under similar conditions.

Cost of the Bulkhead Wall.—The cost of the sea wall varies greatly owing to the broad range of variation in

conditions along different portions of the water front. The examination of the river bottom, the removal of old structures as well as buildings, cribs, piers, sewers, etc., building temporary or permanent sewers back of the bulkhead, building temporary approaches to piers and bulkheads, building temporary bulkheads to retain the filling at the exposed ends of a section of improvement, removing and replacing other structures, filling in, grading and paving, all enter into the element of cost to a greater or less extent according to location, and constitute an item called *general charges*, which must be added to the cost of dredging for the wall area and the cost of the permanent retaining structure in order to determine the total cost of the wall. It will be readily understood that aside from the wide range of variations thus presented, the actual operations in the construction of the wall itself are more or less affected by the same features which enter into the general charges as well as by the relatively cramped or crowded condition of the immediate locality; in fact, to such an extent as to sometimes make the manipulation and operation of floating plant a very serious problem; for it must be borne in mind that the work of these improvements must be so conducted as to avoid any interference with established lines of commerce or traffic. The operations thus rendered necessary, no specific account of which is made in charging up the cost, sometimes result in jumping up the cost 50% or more. These facts are alluded to by way of explanation in accounting for some of the wide differences in cost between the different sections.

For a more convenient synthetical consideration of the cost of the wall, it must be noted that in the following statement the cost is presented under two headings, namely, first, cost of the wall proper, including dredging off the wall area and construction of the retaining structure; second, general charges. The sum of the two for any particular section represents the total cost *per lineal foot* of the *completed* improvement. For the sake of brevity, but three general types will be considered—the rock bottom type, the hard or firm-bottom type and the relieving-platform type, eliminating from the comparison all sections that have involved any very unusual features in the construction to meet specific requirements to such an extent as to deviate materially from one of the three types, or to such an extent as to considerably affect the cost.

	Per lin. ft.
Rock-bottom type:	
For the wall proper the minimum cost has been (East 125th Street Section)	$166.89
The maximum cost has been (West Fifty-second Street Section, Plate XXXVII)	313.83
The average cost has been	260.00
For general charges the minimum cost has been (Broad Street Section)	33.13
The maximum cost has been (East 125th Street Section)	111.50
The average cost has been	47.00
For a completed improvement the minimum cost has been (Broad Street Section)	252.94
The maximum cost has been (East Ninety-first Street Section, Plate XXXVII)	373.11
The average cost has been	307.00
Firm or hard-bottom type:	
For the wall proper the minimum cost has been (Stanton Street Section, Plate XXXIX)	198.42
The maximum cost has been (East Ninety-ninth Street Section, Plate XXXIX)	269.21
The average cost has been	238.00
For general charges the minimum cost has been East 102d Street Section, Plate XXXIX)	24.40
The maximum cost has been (East Ninety-ninth Street Section, Plate XXXIX)	97.13
The average cost has been	58.00
For a completed improvement the minimum cost has been (Stanton Street Section)	241.82
The maximum cost has been (East Ninety-ninth Street Section)	366.34
The average cost has been	296.00
NOTE.—There are no wholly completed sections of this type, consequently the above figures do not include full pavement.	
Relieving-platform type:	
For the wall proper the minimum cost has been (Houston Street Section, Plate XLIV)	217.28

	Per lin. ft.
The maximum cost has been (West Twenty-third Street Section, Plate XLIV).....	392.27
The average cost has been.....	287.00
NOTE.—The average cost for this type of wall used prior to 1899 was $288 per lin. ft. The average cost of the modified type used subsequent to 1899 has been $278.50 per lin. ft.	
For general charges the minimum cost has been (Beach Street Section, Plate XLIV).....	77.83
The maximum cost has been (Gansevoort Section, Plate XLIV)	310.62
The average cost has been.....	206.60
For a completed improvement the minimum cost has been (Beach Street Section).....	304.83
The maximum cost has been (West Twenty-third Street Section).....	572.72
The average cost has been.....	491.30

Of this type, for the wall proper, 11 953 ft. of wall have cost less than $300 per lin. ft., and 5 259 ft. have cost more than $300 per lin. ft.

For an analytical consideration of the cost of the wall proper (dredging and retaining structure) the following figures are given, based upon actual performance in the matter of cost per running foot for the principal items of construction:

Item.	ROCK BOTTOM TYPE.			HARD OR FIRM BOTTOM TYPE.			RELIEVING-PLATFORM TYPE.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Dredging.....	$6.60	$107.00	$30.00	$11.00	$44.00	$32.00	$13.00	$62.00	$30.00
Riprap and cobble..	4.50	12.50	10.40	12.50	19.50	16.00	24.00	84.00	44.00
Piling and timber work.	.....	.....	.....	49.00	62.00	56.50	72.00	139.00	89.00
Concrete and granite..	156.00	309.00	254.00	125.00	133.00	129.50	88.00	139.00	109.00

The following summary of cost for the Warren Street Section of the bulkhead wall built under the prevailing type for soft bottom prior to 1899 shows the distribution of cost per running foot over the various details of construction:

		Per lin. ft.
Dredging		$32.41
Riprap and cobble		60.61
Piling and timber-work:		
Vertical piling	$47.40	
Bracing piles	6.88	
Binding frames	9.32	
Sawing off piles	4.76	
Longitudinal caps	5.12	
Transverse caps	8.37	
Decking	2.74	
		84.59
Masonry:		
Concrete blocks, fabrication	23.89	
Setting concrete blocks	9.35	
Filling chain-holes	1.64	
Granite facing	39.25	
Concrete backing	23.38	
Coping	10.91	
Backing log in place	.74	
Pointing	1.34	
		110.50
Total for retaining wall proper		$288.11
General charges:		
Examination of the river bottom	.05	
Removal of old wall	18.27	
Filling in and grading	10.19	
Temporary paved approach to Pier No. 19	1.19	
Temporary tool house, fences and plumbing	.07	
Levels on and examination of the wall	.14	
Paving	62.20	
		92.11
Total cost of improvement		$380.22

In the cost per running foot for the rock bottom section type of wall all piles and timberwork are, of course, eliminated and the cost of concrete and masonry is greater, but the principal items of difference are:

Pumping off rock and tubbing, which costs about.....$73.80 per running foot.
Bag concrete foundation, which costs about ..... 48.30 " " "

Cost of Making and Setting Concrete Blocks.—As stated before, the blocks in the sea wall vary in size from 30 to 95 tons, and in length on the face from 6 to 18 ft. They are made at the Department yards in mould boxes with sides built of 2 by 5-in., tongued and grooved, planed spruce, battened vertically with 3 by 12-in spruce, and trussed horizontally on about 4-ft. centers, with ¾-in. horizontal steel rods chocked at the center a few inches from the faces of the verticals. Chain grooves for handling, with heavy 2-in. stud link chain slings, are cored in the bottom and sides with a diameter of about 12 in. The inside surfaces of the mould boxes are sludged with hot tallow.

It costs about $1.20 per cu. yd. for erecting, sludging and stripping moulds.

The unit of comparison in concrete work is a batch—the quantity made with one barrel of cement. The concrete being a 1:2:5 mixture, one batch is equivalent to ⅘ cu. yd. and, with a gang of sixteen men, with two men ramming in the moulds, thirty batches or 48 cu. yd. are an ordinary day's work. The cost, therefore, of concrete blocks will average for

	Per batch.	Per cu. yd.
Labor in mixing and depositing concrete, about.	$1.00	$1.60
Materials, about.....	2.90	4.64
Erecting, sludging and stripping moulds, about.	.75	1.20
Total cost, ready for shipment.....	$4.65	$7.44

The cost of setting a block includes derrick charges, transportation, towing, material and labor for mattresses, diver's time, and all other labor charges, and is obviously very much the same for blocks differing considerably in size. The cost, therefore, per cubic yard would be misleading and unfair. A more rational comparison is the cost of setting per running foot of wall, and this averages about $38, making the cost for setting an 8-ft. block weighing 80 tons, the present relieving-platform standard, about..... $304

Cost of block fabricated	$286
Cost of setting block	304
Total cost of an 80-ton block in wall	$590

Notes on Timber in the Construction of the Bulkhead Wall.—The question has frequently been asked, why does the Dock Department risk a permanent work by placing timber above mean low water? The first answer to this question is that the question itself begs the question, for it assumes that any timber above mean low water is in a position to yield to decay; but experience and investigation of the Department do not confirm this theory in so far as it applies to structures in close proximity to the influence of the tide.

The presence of two things are necessary for the decay of timber, namely, *air* and *water*. Decay is prevented by the total absence of either air or water from the wood; for in the decay of timber a slow combustion or oxidation takes place, resulting in a fungus growth which is nourished by the particles of the timber, and the presence of oxygen is necessary for the progress of this action. It is necessary, therefore, in order to prevent wood not absolutely dry from decay, to keep it so wet that air shall not enter its pores. Therefore, it only becomes necessary to determine whether this condition prevails in the timber of the bulkhead wall.

Wherever excavations have been made in the rear of the wall after the filling has been deposited, the tide has been found flowing over the timber; but in order to demonstrate this matter as a fact beyond question, the Engineer-in-Chief at that time, Mr. George S. Greene, Jr., about twenty-five years ago caused two tide gauges to be set up in the rear of the wall on the Leroy Street Section; one about 24 ft. in the rear of the face, that is, at the inshore edge of the relieving platform, and one about 80 ft. in the rear. The points at which these tide gauges were established were in the middle of a completed length of wall about 2 000 ft. long, completely filled in behind. A similar tide gauge was also placed on the pier immediately in front of the wall. The record of the gauge placed in the rear of the timber platform showed that the tide flows over and around the timbers in the wall to very nearly the same extent that it would if they were outside. The gauge 80 ft. inside the wall showed that the tidal flow is somewhat affected by passing through

a greater distance of filling, causing a greater retardation of flow. The curves for all three gauges, being plotted, showed that the tide behind the wall was a little later than that outside and that low water inside was a little higher than low water outside, and high water inside a little lower than high water outside, the difference being about 0.4 of a foot. The gauge 80 ft. inside the wall showed this difference to be about 1 ft., that is, low tide did not fall within a foot as low as low tide outside the wall, nor high tide rise to within a foot as high as high tide outside. Manifestly, the effect of this action of the tide would be to increase the length of time that the timber is submerged, and decrease the length of time that it is not submerged. If the voids and spaces in the stone and cobble filling should in the course of time become silted up so as to oppose greater resistance and cause greater retardation, the effect would be similar to that shown by the gauge 80 ft. inside the wall, increasing the time of submergence and decreasing the time of non-submergence. From the records of the tide gauge outside of the wall, conducted over a period of three years, it appears that if the timber had been outside of the wall it would have been submerged about 66% of the time and not submerged about 34 per cent. The records also show that the earth and stone filling above the timber is saturated and submerged by the tide to nearly the height of mean high water or to about 3 ft., and above this there are about 5 or 6 ft. of earth filling.

In order to ascertain the amount of evaporation under the circumstances of 8 ft. depth of filling with the lower 3 ft. constantly saturated, experiments were made by carefully weighing timber exposed to similar conditions before and after the experiment, and it was found that after the timber had become water-soaked its weight remained practically unchanged; showing an absence of evaporation, due to the tidal flow always keeping the timber wet both from tidal submersion and the saturation of surrounding filling.

The experience of practical men engaged in building timber structures along the water front shows that timber does not rot below half tide. This is certainly the case in piles and in face timbers of crib bulkheads; and the experience of the Department has been that in the rear timbers of such bulkheads which are buried in the earth filling the line of decay is considerably higher

than the line of half tide, and all the experience of the Department in tearing up old work and making repairs, corroborates this statement.

In December, 1877, two specimens of timber were obtained from some old cribwork uncovered by an excavation being made at the corner of Washington and Spring Streets; one specimen was taken from the height of 0.7 of a foot and the other from a height of 3.7 ft. above mean low water. The structure in question existed on maps as far back as 1804 and both timber specimens were in a perfect state of preservation. When the elevated railroad was being built in 1879, near South Ferry, a piece of timber was taken from the excavation for foundations at about 360 ft. from the present bulkhead at an elevation of 2.7 ft. above mean low water. This specimen showed the sap wood on one side to be decayed, but the heart wood was sound. Old maps show that this timber was probably placed where it was found about 125 years ago.

It is, therefore, reasonable to infer that timber in such close proximity to the water front as is used in the bulkhead wall construction would be perfectly safe from decay up to a height of at least 2½ ft. above mean low water; and as the construction of the bulkhead wall where the timber platform is used is practically the same everywhere along the water front built with similar material and in a similar manner and under similar conditions, it is certainly reasonable to conclude that similar results would be obtained by placing tide gauges at other similar points.

Determining the Resultant Thrust.—The method used in the Department at the present time for designating rock sections of the bulkhead wall is believed to be new. The literature on the subject of sea walls is very sparse and far from satisfactory. Any correct analysis for the purpose of determining a resultant thrust at the base is attended with considerable complexity owing to the varying densities or weight per unit of the back filling or filling behind the wall. Accordingly, a couple of years ago the writer, with Mr. D. C. Serber's very able assistance, gave this subject a thorough overhauling with a view to determining a short, graphical, substantially accurate and rational method of analysis. The conclusion reached seems to fulfill these requirements very well. Nearly all authorities agree as to the gen-

eral method of determining the resultant in a retaining structure. But their conclusions presuppose ideal conditions which, it is safe to say, are never realized in actual practice; and no one knows how wide the departures from these conditions really are, more especially in the sea wall with the tide backing in behind into the filling, an unknown and necessarily variable distance. The subject is clouded with a great deal of uncertainty, and after all, it resolves itself into one of those matters in which experience must be a most valuable guide; for, usually, the result accomplished, namely, the cross-section profile is more than likely to bear evidences of analytical control, modified more or less by the dictates of judgment or personal equation.

The conditions given are an approximate cross-section of submerged or of non-submerged wall, submerged sections and non-submerged sections of riprap filling and of earth filling and a surcharge of 1 000 pounds per square foot (see Plate XLVIII.)

Erecting a perpendicular *a d* (see Plate XLVIII) laying off the prism of maximum thrust for riprap by the plane of rupture *a e*, prolonging the line *a e* to *n* and the corresponding prism for the superimposed submerged earth filling by the plane *e k*, which we shall prolong to *m*, neglecting the change in plane of rupture for non-submerged earth filling, we find that the limit for surcharge to be considered at the surface grade is contained between the intercepts *d* and *m*. Considering now everything below mean high water as submerged and everything above mean high water as non-submerged, let us conduct the analysis on the following assumptions:

Let the weight of riprap in air be assumed at 107 lb. per cu. ft.

Let the weight of submerged riprap be assumed at 70 lb. per cu. ft.

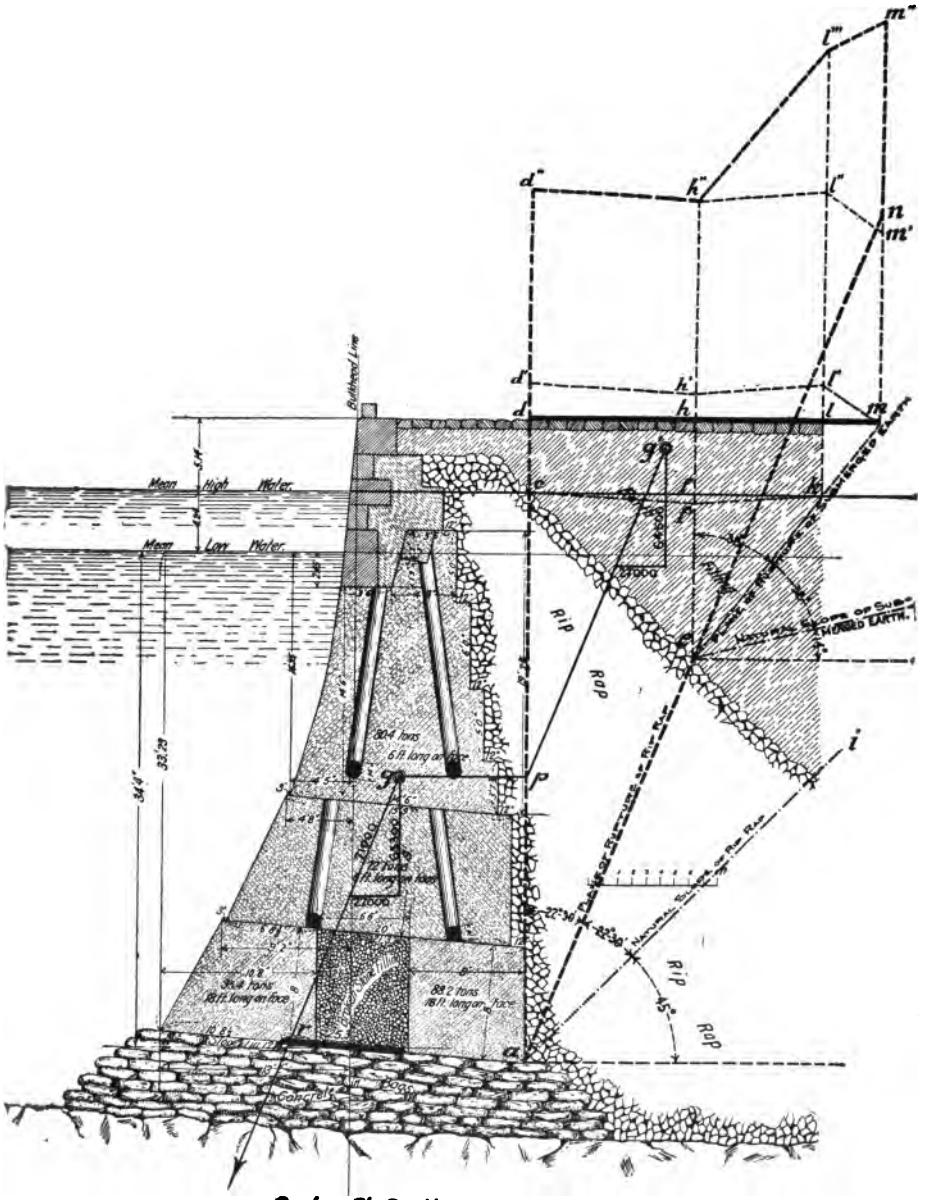
Let the weight of earth filling in air be assumed at 110 lb. per cu. ft.

Let the weight of submerged earth filling be assumed at 66 lb. per cu. ft.

Let the surcharge be assumed at 1 000 lb. per sq. ft.

First.—Determine the weight of the submerged earth filling *c e k*, and replace it with a corresponding weight of submerged riprap. The top surface of the latter will then be *c f' k*.

PLATE XLVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



Second.—Determine the weight of the non-submerged earth filling *c d m k* and replace it with a volume of submerged riprap of equal weight, and allow it to take its position upon the first reduced volume of submerged riprap. The upper surface of this second volume will then be *c d′ h′ l′ m k f′*.

Third.—Take the surcharge of 1 000 lb. per sq. ft. and erect upon the top surface *d′ h′ l′ m* of this imaginary bank of submerged riprap a prism of submerged riprap of such a volume as shall equal in weight the surcharge, the upper surface of this third reduced volume will then be *d″ h″ l″ m′*. We now have the area *a d″ h″ l″ m′ n e a* representing in volume all of the back filling used in exerting pressure against the wall reduced to one homogeneous material, namely, submerged riprap weighing 70 lb. per cu. ft. But in order to avoid the complication arising from a consideration of the two planes of rupture *a e* and *e m*, and, as we have already reduced the back filling to riprap, let us adhere to the plane of rupture for riprap, namely, *a n*, and shift the material represented by the area *e n m* to a new position to form part of the prism limited by the plane *a n*, we have, making *h″* the new position for *e l″ l‴* the new position for *k l′*, and *m′ m″* the new position for *m n*, as the volume to be considered, the weight of submerged riprap represented by the area *a d″ h″ l‴ m″ n a*.

The center of gravity of this area is found to be at *g′*, and combining the weight of the mass through *g′* with its horizontal component, we find the horizontal thrust on the back of the wall to be 27 000 lb. applied at the point *p*. Combining this thrust with the weight of the wall represented by the vertical line 65 300 lb. through its center of gravity, we obtain the resultant, 71 000 lb., which passes through the base at the point *r*.

In determining the center of gravity of the wall section it is of course necessary to consider the reduction in weight due to displacement below mean high water of the two materials, concrete and granite, which enter into its construction, the weight of the non-submerged portion above mean high water, the weight of the submerged riprap on the steps in the rear of the wall, the weight of the superimposed volume of non-submerged riprap and of earth filling.

In this method, which it is believed has never been published

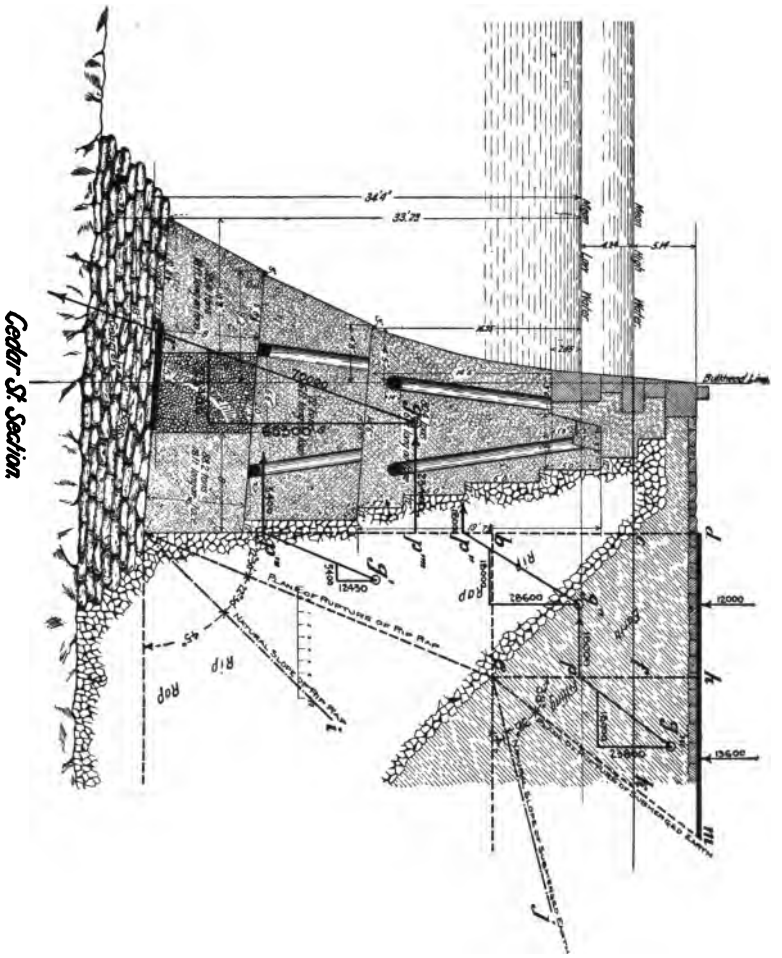
before, no further merit is claimed than that it is shorter, simpler and just as nearly accurate as any other method. It is checked by the fact that the results closely agree with those used in designing the wall for the West Fifty-second Street Section, north end, in 1892, in which the pressures were traced through the different materials, the prisms of maximum thrust being determined in the same way in both cases, the essential difference being the reduction of all the back filling and surcharge to an equivalent of submerged riprap in the more recent designs. It may be urged that this refinement in distinction between the density of the different kinds of back filling is not warranted by the small difference between the weights of riprap and of earth filling; but the motive is to recognize the difference and clear up, if possible, the ambiguity caused by a back filling of materials of different densities. The section of wall referred to (West Fifty-second Street Section, north end) is one of the two deepest rock sections built on the water front, and shows to this day substantially no deviation from line or grade.

The later method was used in designing the Cedar Street Section, now in progress of construction.

Plate XLIX is presented to show the other method of tracing the pressures. Applying the analysis to the same section of wall, and laying off the planes of rupture for riprap *a e* and for submerged earth *e m*, as before, let us, first, consider the pressure of the volume represented by the area *e n m e* with its superimposed surcharge. Combining the centers of gravity of the three different densities represented, that is, the submerged earth filling *e f k*, the non-submerged earth filling *f h m k*, and the surcharge *h m*, 13 600 lb., we obtain the resultant weight, 23 800 lb., through the resultant center of gravity g'''. Combining this weight as a vertical force through g''' with its horizontal component, we get the resultant thrust on *e h*, from which we obtain the horizontal thrust, 18 000 lb., against the vertical plane *e h* at the point *p*.

Again, in the area *b d h e* combine the weights and centers of gravity of the different materials, namely, submerged riprap *b c e*, submerged earth filling *c f e*. non-submerged earth filling *c d h f*, and superimposed surcharge *d h* equal to 12 000 lb., we obtain the resultant weight 28 600 lb. through the resultant center of gravity g''. Combining this force with the horizontal thrust 18 000 lb., we

PLATE XLIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.



obtain the direction of the resultant which strikes the line *a d* at the point p'' with a horizontal thrust of 18 000 lb.

Finally, determining the weight and center of gravity of the submerged volume of riprap represented by the area *a b e* and decomposing the resultant thrust with this weight 12 430 lb. as the vertical component through the center of gravity g', we obtain the horizontal thrust 5 400 lb. applied at the point p'''.

Now combine the two horizontal thrusts at p'' and p''', determine the resultant horizontal thrust 23 400 lb. applied at a point p'''', and combine this resultant horizontal thrust with the weight of the wall, determined as before through its center of gravity *g*, we get the resultant thrust on the base of the wall 70 000 lb. applied at the point *r*.

A comparison of the two methods shows a very close agreement both in the amount, direction and point of application *r* of the resultant thrust.

Freight Sheds and Recreation Buildings.—Freight Sheds.—As a rule, freight sheds are erected upon piers and bulkheads by the owners or lessees; if by the latter, these structures, by a covenant in all leases, revert to and become the property of the city at the termination of the lease. In some cases the city builds the sheds. Of the more modern structures the city has built three on the North and three on the East River. There is nothing novel or striking in their construction. They are the simplest type of steel framed structures of one or two stories, as the case may be, with particular attention given to the bracing, owing to their exposed condition and the vibrating nature of their foundation.

In all cases in the open waterway, that is, within the pier area, the foundations consist of piles arranged in clusters as nearly symmetrical with the concentration as may be, on not less than 30-in. centers, to carry from 12 to 15 tons per pile. This often requires in a double-deck freight shed, where the upper story is designed to carry a live load of 300 lb. per sq. ft., foundations comprising from 9 to 20 miles in a group. The transmission from the foot of the column to the pileheads is made uniform by a tapering system of "cobbing up" with 12 by 12-in. yellow pine timber from the tops of the piles, which are capped as low down as may be necessary to secure the proper distribution by tapering the courses

of chocking up to a 3-ft. square base for the columns at the top of the foundation, which is usually at the deck grade.

An effort is made to determine in advance of the pier construction just what column loads and distribution will have to be provided for, and the requisite foundations are usually built with the pier.

In the West Fifty-ninth Street pier a device was tried for securing an incombustible foundation by capping the foundation piles at low water, and supporting the column upon a concrete pier, resting upon and keyed to a grillage platform, fastened to the capped piles.

The inshore portion of a freight shed for a length of from 60 to 100 ft. is usually built with two stories, for offices in the second story. The main entrance for teams generally provides for an in-and-out driveway, flanked on each side with entrances to the office portion of the building. A very cheap and weather-proof wall for the office portion of a freight shed is constructed of 8-in. channel iron framing (studs and girts) sheathed on both sides with 1-in. matched spruce or hemlock boards laid diagonally and fastened to 2-in. nailers, bolted to the framing with carriage bolts, the spaces between the outer and inner sheathing being filled with mineral wool well packed, but not enough to spring the sheathing. The sheathing is then covered with resin-sized building paper, well lapped, outside of which on the exterior surface may be fastened galvanized, corrugated, crimped or smooth iron as may be desired for architectural effect, the architraves, pilasters, window sills, lintels, moulding, cornices, etc., all being formed of galvanized sheet iron. The interior of the offices may be finished off with matched and beaded yellow pine, ash, plaster or stamped metal, as may be desired. Plaster, however, is not to be recommended where the structure stands upon such a vibrating foundation as a pile pier.

The minimum head room for the entrance of teams should be not less than 15 ft. In the main portion of the shed the head room varies from 15 to 30 ft., according to the special purpose for which the shed is built. The tendency at the present day is to high freeboards in ocean steamers, requiring correspondingly high openings in the sides of a shed for loading and unloading freight and merchandise.

Freight sheds are built with bents on 20-ft. centers, coming over pile rows, throwing the construction of foundations into the rows, thereby minimizing the obstruction to the flow of tide water in the open bays of the pier. This spacing of shed bents is the unit of construction, determining all questions of economy in design. As before stated, the side openings vary in width and height, according to special requirements, reaching a maximum in a steamship shed, the width being controlled by the spacing of the columns, which seldom exceeds 20 ft. on centers. The height of openings reaches a maximum of 24 ft., but this particular limitation is as much due to the requirements of simplicity and strength of door construction combined with facility in handling as it is to the freeboards of vessels. The design of a perfect door for freight sheds furnishes a broad field for study. Such a door must be capable of being operated rapidly by one man, with the wind blowing thirty miles an hour in all kinds of weather.

A well-designed freight shed will have a continuous lantern or ridge ventilator, extending from end to end of the main building, varying in width according to the width of the shed and controlled entirely by the panel spacing in the roof trusses.

The roof covering may be tin, slag and cement, tar and gravel or metal tiling, depending upon its slope. Slag and cement make about the cheapest and most durable roof covering, costing about 4½ cents per sq. ft. It is adapted to slopes as high as 22 or 23 degrees. The width of span enters largely into the determination of slope, but where practicable a pitch of 20° or more is far more economical than a flatter pitch, for aside from the undoubted economy in steel sections in a steeper roof over a flatter one, the present Building Code prescribes that a live load of 50 lb. per sq. ft. in addition to the weight of the roof structure shall govern the design of roofs having a pitch less than 20°; whereas, for pitches exceeding 20° the live load shall be taken at 30 lb. per sq. ft., making the weight of a roof truss in the former instance about 7½ lb. per sq. ft. of roof, against 5 lb. per sq. ft. in the latter.

Cost of Freight Sheds.—As usually constructed, the cost of the principal items in the construction will approximate:

For structural steel erected, 50% of the contract price.

For lumber in place, 8% of the contract price.

For sheet metal, 11% of the contract price.

For roofing, 5% of the contract price.

For appurtenances, 13% of the contract price.

For painting, 8% of the contract price.

For miscellaneous, 5% of the contract price.

The cost of the main portion of the building in different freight sheds will vary but little per cubic foot. The cost of the office portion will, of course, depend upon the elaboration in construction, appurtenances, etc.

With steel at $60 per ton, erected, the cost of a single-story freight shed will average:

For the office portion, about 10 cents per cu. ft. of enclosed space.

For the main portion, about 3.8 cents per cu. ft. of enclosed space.

For the entire freight shed, about 5 cents per cu. ft. of enclosed space, or

For the office portion about $3.95 per sq. ft. in plan.

For the main portion, about $1.13 per sq. ft. in plan.

For the entire freight shed, about $1.54 per sq. ft. in plan.

For a double-deck or two-story freight shed the cost will average:

For the office portion, about 10 cents per cu. ft. of enclosed space.

For the main portion, about 6¼ cents per cu. ft. of enclosed space.

For the entire freight shed, about 6¾ cents per cu. ft. of enclosed space.

Manifestly, any estimate based upon area is likely to give misleading results; for the amount of material in two structures of the same ground plan will vary according to their relative heights. The above figures for rate per square foot of enclosed space may, therefore, be used only for very rough or rapid estimating. The rates per cubic foot are, however, quite reliable.

Recreation Buildings.—Since the early part of 1897, the Department has built eight recreation buildings on piers belonging to the city. In Manhattan, there are three on the North River and four on the East River. In Brooklyn, the old city before consolidation had commenced the building of one under contract at the foot of Metropolitan Avenue, which was condemned by the Department of Docks when, under consolidation, in 1898, this work

FIG. 1.—PROMENADE DECK OF RECREATION PIER AT FOOT OF E. 24TH STREET.

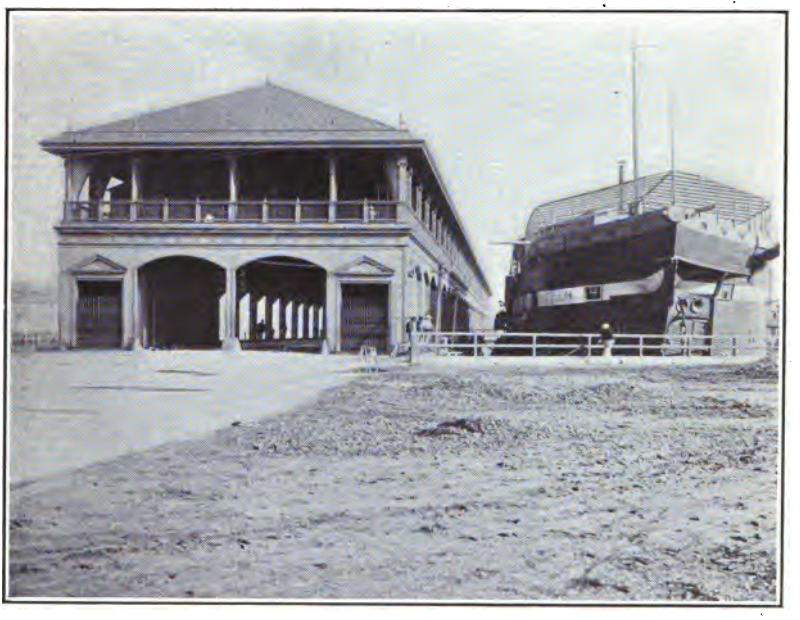


FIG. 2. RECREATION PIER AT FOOT OF E. 24TH STREET.

passed into the hands of that Department. The construction, however, as far as it had progressed, was made available by the Department by alterations and additions for strengthening, and the building was completed. These buildings have all been built under contract. They are from 45 to 62 ft. wide, from 202 to 722 ft. long, and 45 ft. high from the deck of the pier to the ridge of the roof. The largest building is on the pier at the foot of East Twenty-fourth Street, Manhattan (Plate L). They are built of framed steel, ornamented with moulded cast iron and galvanized sheet iron. The second story is open throughout, and, with the exception of the Market Slip pier, have toilet rooms for men and women on the lower deck. In the Market Slip building (Plate LI, Fig. 2) they are on a mezzanine floor.

They are all equipped with such appurtenances as soda fountains, fruit stands, drinking fountains, band stands, settees, etc. They are open to the public from June 1 to October 1, during which period they are abundantly lighted during the evening with arc lamps in both stories. Band concerts are given every evening throughout the season. Each building has a corps of male and female attendants, the maintenance of the recreation buildings being under the supervision of the Superintendent of Docks.

The lower story is devoted entirely to light commercial purposes, the upper story being used alone for recreation purposes.

The recreation buildings have cost from $50 000 to $150 000, according to size, but a person has only to visit one of these buildings, like that at West Fiftieth Street, on some sweltering midsummer evening, to understand and fully appreciate and indorse the magnificent gratuity which the City of New York is extending in this way to the people in the crowded tenement sections.

The building at the foot of East Third Street has for two or three years been used by the Department of Education during all but the summer months as a public school. For this purpose the second story is partitioned off from the weather and into class rooms; a false floor is laid and the rooms are steam heated from a plant on the lower deck.

It may be interesting to note that these buildings have cost as follows:

Location.	Dimensions.	Cost per lin. ft.	Cost per sq. ft.	Cost per cu. ft.
East 3d Street	52 x 302	$175.40	$3.37	18. c.
East 24th Street	52 x 722	197.00	2.68	11.3 c.
East 112th Street	52 x 202	210.00	4.04	21.6 c.
Christopher Street, N. R.	45 x 441	165.21	3.67	19.9 c.
West 50th Street	52 x 642	173.29	3.33	17.5 c.
West 129th Street	52 x 302	200.00	3.84	20.4 c.
Market Slip Pier, E. R.	62 x 305	397.50	6.48	.....
Metropolitan Ave., Brooklyn	51 x 206	145.27	2.85	.....

The cost of the recreation buildings, shown in the foregoing, does not include the cost of the pier or the cost of foundations, excepting that in the case of the Market Slip recreation building the cost of foundations and of redecking and resheathing the pier are included. The comparatively high cost of this building is due to this combination, and also to the fact that at the time the contract was let, steel was 50% higher than in the other cases. In addition to this, the Market Slip building has a water-proof floor in the promenade deck. The Metropolitan recreation building is a cheaper type of building, both in structural features and in appurtenances, than any of the others. The comparatively low cost of the East Twenty-fourth Street building is due to its great length and consequent repetition in structural details. Eliminating, therefore, these three buildings from the general list, it appears that the average cost of the recreation buildings is about $3.65 per sq. ft. of covered space, or about 19½ cents per cu. ft. of enclosed space.

Repairs, Paving, etc.—A very considerable portion of the Department work is occasioned by the continual repairs required by timber structures. Any work of large magnitude of this nature is done by contract, otherwise it is done by the Department's own labor and materials.

Four classes of pavement are handled by the Department. Newly filled-in land is usually paved with granite on 3 in. of sand; more compacted filling or filling in which settling has practically ceased is usually paved with impervious granite pavement, laid upon a concrete foundation; asphalt pavement where required is usually laid directly upon the granite pavement. Where pavement is laid in remote or unimportant localities second-hand trap or granite blocks are used.

The surface drainage from all Department pavement is either

PLATE LI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOAG ON THE NEW YORK
DOCK DEPARTMENT.

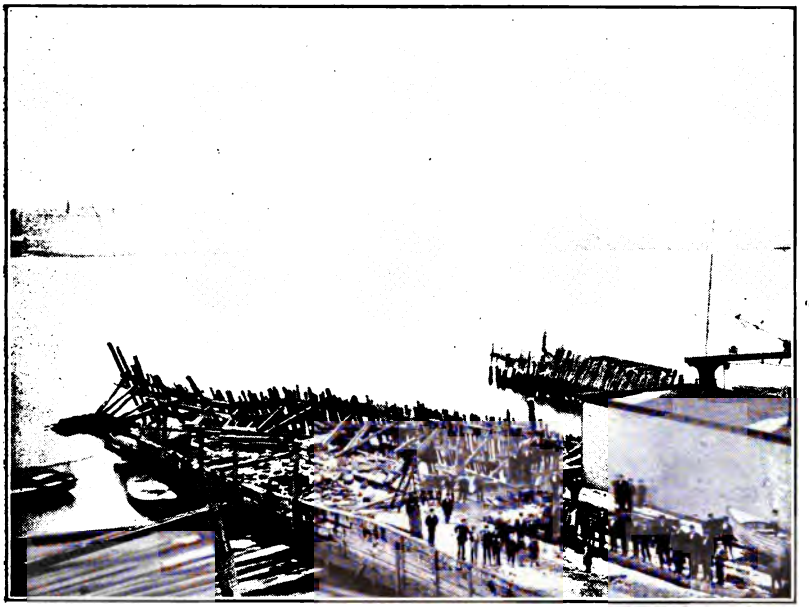


FIG. 1.—DELAPIDATED WATERFRONT STRUCTURE AT TIME OF CREATION OF DEPARTMENT OF DOCKS.

FIG. 2.—RECREATION PIER (NO. 30, E. R.) NEAR FOOT OF MARKET SLIP, E. R.

carried directly over the bulkhead wall or provided for by a separate system of cast-iron pipe sewerage with manholes and catch basins. The catch basin used by the Department is a 1 200-lb. casting and has a discharging capacity for about one-quarter of an acre.

There are at present about 265 700 sq. yd. of marginal streets, graded and paved, mostly with asphalt.

Department Plant.—For all work other than contract work the Department has two depots for tools, material supplies and floating plant—the West Fifty-seventh Street and the East Twenty-fourth Street yards. A pile and timber basin is located at and near the foot of West Seventy-second Street, North River. The West Fifty-seventh Street yard is the headquarters for the floating plant. Concrete blocks are fabricated at both yards. Granite is cut at the East Twenty-fourth Street yard, the Twenty-fifth Street pier being equipped with an electric gantry crane for the storage and cutting of granite.

The floating plant, valued at $500 000, comprises:

One 100-ton derrick, 70 ft. long, 65 ft. wide and 10 ft. 3 in. draft, named the *City of New York* (Plate 21).

One 40-ton derrick, 70 ft. long, 30 ft. wide and 5 ft. draft.

Two 12-ton derricks, 70 ft. long, 30 ft. wide and 7½-ft. draft.

One 10-ton derrick, 40 ft. long, 35 ft. wide and 3½-ft. draft.

Three tugs, named *Manhattan, Brooklyn* and *Richmond,* from 98 to 110 ft. long, with about 10-ft. draft, the *Brooklyn* being a steam lighter.

Sixteen pile drivers, about 45 ft. long, 25 ft. wide and 2 ft. 10-in. draft, several of which have adjustable ways for driving batter piles.

Sixteen deck scows, 70 ft. long, 30 ft. wide and 6-ft. draft.

Five divers' scows, 34 ft. long, 17 ft. wide, with 1-ft. draft.

One boring machine, the *Woodcock,* 28 ft. long, 14 ft. wide, with 2-ft. draft.

Two steam launches.

Three naphtha launches.

Forty-seven yawls, sounding boats, skiffs, etc.

Two sets of landways for pile driving.

One set of inclined ways for driving batter piles.

The 100-ton derrick has been in almost continuous use since 1871, and is used principally for handling and setting the concrete blocks. The 40-ton derrick was built for carrying on the work of setting concrete blocks to avoid delaying the construction of the wall during a period a few years ago when the 100-ton derrick was taken out of commission temporarily for very necessary repairs. It is still used for setting concrete blocks, up to its capacity. The 12 and 10-ton derricks are used for any of the lighter work, principally in setting granite. These derricks are equipped with an 8-in. pump for cleaning off rock in building a rock section of bulkhead wall. The pile-drivers, besides being used for driving piles, also render good service in the capacity of derricks and for tearing up and removing old work, the capacity for which is principally determined by their flotation. The deck scows are used for conveying material like sand, broken stone and cement, paving blocks and concrete blocks, etc., and is also used for mixing concrete by hand at the site of the work. The divers' scows are manned by two pumpers and a diver's tender. The boring machine is used for taking hydraulic borings, ordinarily called wash borings or strata borings. The steam and naphtha launches are used by the Department Engineers and other officers for inspection and examination. The yawls, sounding boats, skiffs, etc., are used for communicating between the shore and any of the floating property that may be moored or anchored in the vicinity of the work, but otherwise inaccessible from the shore; also by the hydrographers for taking soundings and by the engineers for making inspections and examinations.

The completion of the five new ferryboats, which will be named after the boroughs, and which will be used in operating the first municipal ferry, will form a very important addition to the fleet of vessels owned and operated by the Department. They will be the largest and fastest ferryboats in New York Harbor, and while they will not form a part of the Department plant, they will become important members in opening a new era in the Department and, in fact, of the city, marking one of the first steps in the progress of municipal control of public utilities.

Expenditures and Revenues.

The fund for maintaining the Department, for paying all expenses of administration, engineering, labor, materials and supplies for new construction work, contract work and repairs and for purchasing property, is derived from the sale of corporate stock by the Comptroller, authorized by the Board of Estimate and Apportionment, to the amount of $5 000 000 in any one year, and a larger sum by the approval of the Board of Aldermen, in case it can be shown that it is needed.

The figures showing the relation between expenditures and revenues for 1904 have not yet been completed and are not at present available. The corresponding information for 1903 shows an expenditure of over $4 000 000 for the purchase of property alone, or 25% of the whole amount expended for this purpose in thirty-three years, and the results of any comparison during the year 1903 would, therefore, be unfair and misleading. Taking therefore, the figures down to the end of 1902, as representing a more nearly normal condition, we find that the improvements made and all other work done by the Department between the date of its organization and January 1, 1903, have cost for

Administration dock superintendence and the Bureau of Accounts	$2 444 735.00
Engineering	2 238 170.82
Labor, materials and supplies for new construction work, contract work and repairs	34 453 965.50
Acquiring property	11 700 520.24
Or a total of	$50 837 391.56

The revenues received by the Department during the same period are:

From ferry leases and franchises	$7 919 726.37
From leased wharves and wharfage	44 490 625.45
Or a total of	$52 410 351.82
Showing an excess of revenues over expenditures for this period of	1 572 960.26

Notwithstanding the fact that such a large percentage was paid

for wharf property acquired and for the permanent improvement of the same.

For the year 1902 the total gross revenue amounted to.$ 2 976 739.77
Equal to a capitalization at 3½% of more than..... 85 000 000.00
On an expenditure of a little less than..... 51 000 000.00

Out of which $1 250 000 have been expended in building piers, bulkheads and providing other accommodations for various City Departments, from which no revenue can accrue, and for which the Department receives no credit in the accounts for the saving to the city in rentals for such accommodations, and $600 000 for erecting seven recreation buildings, requiring an annual expense of about $160 000 for maintenance, another item which excludes any revenue.

The gross expenditure of $51 000 000 from May 1, 1870, to January 1, 1903, has resulted in the construction of

214 piers and platforms, with a total area of 5 606 000 sq. ft.

17 550 lin. ft. of crib bulkheads.

30 575 lin. ft. or 5.8 miles of permanent bulkhead or sea wall.

4 600 000 sq. ft. or 1 840 city lots of filled-in or reclaimed land.

Several miles of marginal street, graded and paved to the extent of 265 700 sq. yd., mostly with asphalt.

Eight steel freight sheds on piers.

Seven recreation piers.

Two Department yards valued at $500 000, equipped for carrying on the Department work.

A floating plant valued at $500 000.

It is safe to estimate that the extensive improvements now under way on the North and East Rivers will increase the annual revenue within the next two years to $4 000 000.

But revenue is not the sole advantage derived from this expenditure of money, for aside from any consideration of the Dock Department's being financially a paying investment for the city, the beneficent results accruing from the ever-increasing commerce at-

tracted to this port, by the advantages afforded by the improved wharfage facilities, are far reaching; they are not merely local, but extend beyond the bounds of the State itself. They are national in scope and influence.

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DISCUSSION.

HORACE J. HOWE, Member of the Society.—In these days of investigations and revelations of the inside workings of corporations and companies, this paper should not occasion surprise perhaps; but twenty-five years ago, when the speaker first made the acquaintance of the Dock Department, a similar paper would have occasioned great surprise; containing, as it does, things that many an engineer has wondered about, but has never seen collected in any such condensed and valuable form.

The Dock Department appears to be an engineering stock company, exhibiting perennially, for those sufficiently interested to take cognizance of what it is about over its miles of water front, and we have in this paper a scientific explanation of the pantomime, or, if you prefer, the legitimate drama.

The outsider cannot hope to do the subject justice and can only take up a few points.

Below are some figures giving the contract prices of dock work, constructed by the Erie near its elevator, Jersey City, in 1879.

Guidet & White, Contractors, August, 1879:

Riprap in place, per cubic yard	.65
40 to 60-ft. spruce piles, driven, per foot	.05¼
60 to 70-ft. spruce piles, driven, " "	.18½
4-in. yellow pine lumber, per M.	28.60
4-in. spruce sheathing	18.50
Oak fenders	41.00
Wrought iron, per pound	.03½
Cast iron, per pound	03½

Labor included and no allowance for scarfs, waste, etc. The price for spruce piles 40 to 60 ft. was too low. The actual cost was about 12 cents.

Wood, Contractor, June, 1879:

40 to 60-ft. spruce piles, per foot	.12
60 to 65-ft. oak mooring piles	.25
Dimension yellow pine timber, per M. B. M.	25.00
5-in yellow pine deck and 4-in. braces	25.00
4-in. spruce sheathing	16.00
Oak fenders, per M. B. M.	50.00
Wrought iron, per pound	.05
Cast iron, per pound	.03

The above price for yellow pine timber was too low, actual cost was $29 per M. B. M.

The author states, and I get it from other sources, that there has been little change in the general principles of pile pier construction since that time.

The estimated cost of the column spoken of, built up of four pieces, 10 by 10 in. by 84 ft., at that time, was $86 driven, and I am glad to hear the result of the experiment.

The teredo of those days seems to have been a much more reliable animal in his activities than he has been of late, for it is good practice now to build costly structures upon piles without preservative treatment of any sort; relying upon the renewal of the piles by cut-off, as decay proceeds, and upon the change of heart of the teredo.

Speaking of chocks between the heads of piles, there was built in 1884, at Duluth, a pile trestle for a single track railroad, a mile or so long across the St. Louis River, which was considered at the time quite an experiment, in view of the ice gorges at that locality. It was strongly braced and had besides at the water line, 10 by 10 in. chocks between the piles, which chocks were protected by a double line of horizontals. I believe that a large measure of the success in resisting ice was due to those chocks.

The author recommends the round ends for piers; and this would apply to all draw-rests undoubtedly. Sharp corners suffer when a one-thousand ton barge brings up square against them.

As for warehouse sheds on piers, we used wooden Warren girders in 1880 on the Erie and whitewashed them. Steel was not a distinct advance until used in connection with concrete, the latter acting in the dual capacity of a bumper against shocks and a preservative of the metal. Novelty siding was used, also pitch and gravel roof. Skylights were avoided as causing leaks, owing primarily to the movement of the pier.

With regard to pile formulas, there is one point which seems to have escaped the author:

A formula depends, I think everybody will agree, upon the conditions at the time of dropping the hammer, and the consequent set; conditions which change more or less as time goes on.

We will suppose that the engine-man cannot be trusted and that therefore it is necessary to cut the hammer line at the top of the ways, so that there is left only the question of plumbing the ways, the friction on the sides and the brooming of the pile head to be watched. The set is taken and, in a general way, indicates the load which the pile will stand at the time. If we wait over Sunday or longer, and make the same test, the set will usually be different, or we will say smaller, and therefore the formula must be given another chance for its life.

If there is in the specifications a clause to the effect that for a

2 000 or 3 000-lb. hammer with a 10 or 15-ft. drop, the set for the last blow must be so and so, the contractor is not very bright if he does not make his "last blow" a few days later. In case of trouble with the inspector, it might be found that he had conformed to the letter of the specifications and therefore had good grounds for a suit.

As to kinds of soil, I think there is a happy-go-lucky impression among engineers that piles are bound to be much better later on than at the time of driving. Sometimes a settlement does not matter very much, speaking from the point of view of expense of maintenance.

The author speaks of adding to the top of the bulkhead wall at no great expense. The same might be true on many a pile platform or railroad trestle.

In the case of costly buildings or bridge towers, on the contrary, the expert engineer takes no chances. There is no let-up to the load, and it takes advantage of any of the mistakes of the engineer. My experience with clay is, that the supporting power does not increase with time in the proportion that it does in the case of swampy or alluvial ground. I have it on the authority of others that sand sometimes gives under repeated vibrations. It may be hard to drive the pile into the sand but afterwards the settlement occurs. Perhaps the most noted instance of the failure of piles in clay is that of the London Bridge, finished in 1209 A. D. and removed to give place to the new bridge in 1825. This gives us a clue to the age of the game we see the children play, familiar to all: "London Bridge is falling down," etc.

Nearer home, we have the failure of the nine arches of the South Street Bridge in Philadelphia back in the seventies. This bridge stood for a period of six or seven years before falling and the theory is that the piles penetrated almost through the hard stratum, say to within 2 or 3 ft. of the upper limit of the mud pocket, and that the tremors produced by the heavy and constant travel had a tendency to loosen the piles and allow the surface water to lubricate them. In time the pressure was too much for the point of the pile.

There are many causes that tend to reduce the bearing power of a pile, speaking historically. Earthquakes are, of course, more serious in many places than here. The seismographs at Washington and Baltimore, however, show to the scientific eye how many more movements there are of the earth's crust than are ordinarily apparent.

Lightning bolts in the vicinity of a pile foundation tend to shake the relation between a pile and its encircling neighbor, the compressible soil. Dynamite is not so uncertain in its movements,

and the amount of it that is used about the city runs into tons that appall us. In Jerome Park Reservoir there has recently been used over a quarter of a ton per day. No wonder that the neighboring Metropolitan power house has a floor of concrete 7 or 8 ft. thick over its 40-ft. piles.

In conclusion I would say that this paper is noteworthy as furnishing a constant guide along the lines of which it treats, and furthermore is a praiseworthy contribution to technical literature.

STEPHEN U. HOPKINS, Member of the Society.—In regard to the bearing power of piles where it is impossible to get a solid foundation, the following from my own experience may be interesting. At the Twenty-third Street Ferry of the Pennsylvania Railroad the depth of the alluvial mud of the river bed is about 175 feet. In building the sea wall and ferry house, of course, pile foundations had to be used. In order to ascertain to some extent the bearing power of piles driven in this mud, the following test was made: four piles, each 80 ft. long, 15 in. in diameter at the larger end and 7 in. at the smaller end, were driven in a group. The average penetration per blow for the last five blows of a 3 000-lb. hammer falling 11 ft. was 14 in. The piles thus driven were allowed to stand four days, then loaded with 80 tons of pig iron (20 tons per pile) and allowed to stand thus loaded for seven days, during which time there was no settlement detected in the pile group. The depth of water (mean low water) was 19 ft. and the piles were 7 ft. above mean low water, hence there were 54 ft. of the length of the piles in the mud (pile 80 ft. long).

I will state further that when these test piles were pulled up floats had to be used to give the pile-driver more buoyancy and even then it was found necessary to use the hammer in order to start the piles.

WISNER MARTIN, Member of the Society.—I should like to call attention to the fact, which Mr. Howe has brought out, that in using a formula it might give a satisfactory result at the time the pile is first driven, but in the kind of alluvial mud which we have here along the North River, that if the pile is allowed to stand over Sunday it will bear a good deal more load; consequently the formula would not give the safe load correct; it would give less and I think if Mr. Hoag did not actually say so, he intimated that they found it safe to put twice as much on their piles as the *Engineering News* formula would allow.

I also had a similar experience to that of Mr. Hopkins in Jersey City. We had occasion to drive there a 60-ft. pile in mud, simply for a locating line, and it went down under a 2 000 lb. hammer with hardly a blow, the hammer pushing it down by its weight only; but the next day, when it was no longer needed, we

found it firm, when we started to pull it up. The lash line which we put around it and which was connected to the fall rope to pull it up, held fast and the deck of the pile driver was put under water but it did not start. We had to put the hammer on it and start it down again and then, after breaking the bond with the mud, we could pull it out readily, showing that this alluvial mud is very adhesive and that it certainly puts Wellington's formula to a severe test. Of course, it is not scientific to say these things, but still experience teaches us that we can go very far above the theoretical safe load in this particular kind of soil. I have had the same experience that Mr. Howe speaks of with regard to piles driven in sand: that they are very much more reliable, although they are very much harder to drive. I think where there is a live load going over the piles in sand they are unreliable.

JOHN C. WAIT, Member of the Society.—In regard to pile-driving, I have been having some experience in trials where pile-driving has been of real importance, especially in building a sea-wall, and there is no subject in engineering that requires more care, more anxious study and more careful design than this subject. How shall a pile foundation be constructed for a wall or dock behind which filling is to be made? I have noticed in dock work, without criticism of anybody, especially along the Harlem River and where it has been braced and anchored with cables and with other devices, and it has gone out, and when built after plans approved by the Dock Department. It may have resulted from having to use piles very much longer than was contemplated.

On the Erie Canal in Syracuse, in 1896, I put a wall along what was known as the Grave Yard. A system of pile foundation was built with a heavy wall on it and it was filled in behind. With 18 in. of dirt it went out. For 1 000 ft. along the wall they grilled the whole bottom of the canal to retain this foundation. The problem is how to brace your piling, whether by anchors and tie timbers, or by toe piling to resist the lateral pressure.

I have in mind also the sea-wall at Annapolis, on which several reports of the Navy engineers were made, the design changed two or three times, and experiments made extending over three or four years. A record of every pile driven was made and the wall went out and settled. This Annapolis work was, I think, attended by one of the most extensive systems of pile-driving experiments. I don't think that the results have been published; if they were, it would be an interesting publication on the subject, when taken with the results obtained. In that work at Annapolis and, also, in the work on the Dry Docks in Brooklyn, in which the famous Walsh litigation arose, the pile-driving was overdone and piles were telescoped. Some of the piles were driven to destruction and others settled, almost of their own weight.

MR. HOWE.—A number of years ago I tried to get that data from Annapolis. I wrote to two or three persons but I could not get anything whatever.

MR. WAIT.—All that data is in the hands of Mr. Ernest Flagg, architect, of this city, and it is also in the hands of the Navy Department.

LAZARUS WHITE, Member of the Society.—Page 121 of Mr. Hoag's paper shows the movement of dock walls in New York. They seem to be very small, so they must have about solved that problem, I should imagine.

MR. MARTIN.—I should like to ask if Mr. Wait will give us an idea of what kind of a design was used for this retaining wall at Annapolis. Can you sketch it on the board, Mr. Wait?

MR. WAIT.—(Sketch made on board and explanation given.) After the piles were driven they were sawed off. The requirements were that there should be a maximum variation of 1 inch. The contractor claimed that that was satisfied by being within 1 inch of the datum plane. The Government contended that it should be within ½ inch of datum. The plan was abandoned at the instance of the engineer and it was built by a thoroughly new method. Caissons were built and floated. They were made of 12-in. timber for a bottom, the sides being of 4-in. stuff; they were assembled on shore, floated to the pier foundation, anchored over it and filled with concrete.

The profile for this work showed that the piles would be from 20 to 60 ft. long. The profile was made from borings made with great care. The work required piles from 60 to 100 ft. long. They averaged about 80 ft.

MR. WHITE.—I would like to ask Mr. Wait in what respect the wall went out?

MR. WAIT.—When they began filling, the wall went out laterally.

MR. WHITE.—Any bracing behind?

MR. WAIT.—No bracing whatever.

THE AUTHOR.—Will you tell us whether the filling was put in from the wall or from the land side?

MR. WAIT.—The filling was put in towards the land.

MR. THOMPSON.—I would ask Mr. Hoag, at what angle do you drive the spur piles?

THE AUTHOR.—Eight feet horizontal to 12 ft. vertical. It was a little late when I entered the hall, and I have not heard all of Mr. Wait's remarks, but I heard Mr. Wait say that a number of bulkheads approved by the Dock Department had gone out into the river. That is true in a single instance, with which I am familiar only by tradition as it occurred nearly twenty years ago. But the cause of that occurrence was no fault of the bulkhead; it was

wrecked because of improper filling in behind. If proper care is not taken in filling in the rear of any bulkhead or similar retaining structure, it is safe to wager that it will go out, unless the filling is deposited from the bulkhead towards the shore. It is the universal custom in the Department to deposit filling in this manner, thereby driving the mud wave shorewards.

MR. WAIT.—I would like to ask the gentleman if he intends creating a dam.

THE AUTHOR.—Not at all. There is nothing at all approaching the character of a dam in our bulkhead construction. The section referred to was built upon piles in a mud bottom 150 ft. thick with piles of a maximum length of 80 ft., cut off to a grade of about 15 ft. below mean low water. That stretch of wall extends from West Twenty-third Street to West Thirty-fourth street—a physical proof of what can be done in the matter of supporting a wall by mud flotation. In the stretch covered by the Gansevoort and Chelsea sections a still more dangerous condition exists because of the fact that the area occupied by the wall was excavated in material consisting of old filling upon the same kind of mud bottom, viz., a deep mud bottom. It is a very hazardous thing to undertake to predict just what is likely to happen in the rear of a bulkhead wall where the original filling of this nature has been partially removed and dredging carried to 40 ft. below mean low water in front of the wall, the undisturbed prism in the rear of the wall being relieved from the support and back pressure of the excavated material in front. I must confess that the problem caused us to think seriously in designing the Chelsea section; but as for undertaking in any sense to construct a dam, that idea was never thought of or attempted. It is not necessary to make the foundation under a wall with a relieving platform any more stable than sufficient to carry the weight of the structure and a surcharge. That portion of the wall between Twenty-third and Thirty-fourth Streets has settled as much as 4 ft. at the southerly end. The character but not the exact amount of settlement was anticipated in the design and construction of the wall. For this particular stretch of wall crosses what was formerly a sort of bay along the North River water front, requiring an extensive filling in of the intercepted or land-locked area, and it is probably certain that the filling when placed in the rear of the wall must have displaced a large mud prism, which in its endeavor to acquire a condition of equilibrium pushed material between the piles and carried the whole mass of the bottom, including the pile foundation for the wall and relieving platform, riverward or outshore, creating a depression into which the wall sank. This theory seems to be evidenced by the fact that a portion of the wall developed a shoreward movement due

probably to the piles canting towards the river, tilting the wall backwards.

But the point that I would like to impress upon the gentleman who preceded me is, that he must not be deceived by the phenomemon of a bulkhead going out into the river, into necessarily condemning the design or construction of the bulkhead. Our observation has led us to conclude that as a rule filling in in the rear of bulkheads is ignorantly conducted.

MR. HOWE.—I should like to ask the author about the piles that settled: if those were the ones that stood the load pretty well and what was the cost of setting them?

THE AUTHOR.—The wall began to settle the moment the blocks, that is, the concrete base blocks, were set upon the piles, showing that it was probably due to a compression of material into which the piles were driven. Of course, no one can tell what has actually happened in that pile foundation; but the gross result was predicted in accordance with a certain theory.

TYRRELL B. SHERTZER, Member of the Society.—I would like to ask an explanation of an incidental remark of Mr. Hoag's. Why will back-filling from behind a bulkhead wall towards the shore line have less effect on the wall than filling from the shore line out?

THE AUTHOR.—No one knows how far the influence of that mud wave extends vertically. What we seek to obtain is a movement from the wall inshore, if a movement is to be created, and under no circumstances towards the wall. Drive the mud wave away from the wall shorewards. Our filling, by the way, immediately in the rear of the wall is a rip-rap embankment. The philosophy of this rip-rap filling is apparent in the design of the wall section. The rip-rap will stand a slope of about 45° in still water; whereas, mud or saturated earth filling has a slope of about 14°. The governing slope in the prism of maximum thrust which determines the pressure against the rear of a sea wall, and which, therefore, determines its design, is the natural slope of the material used in the back-filling; and manifestly the material which under all conditions will stand at a steeper slope will produce less pressure than material which requires a flatter slope. It can, therefore, be readily seen that rip-rap is almost an ideal filling in the saving of material in the wall itself, for the prism of maximum thrust determines also the extent in area of surcharge to be considered. If cinder filling could be used behind a sea wall a still greater saving could be accomplished, for cinders are much lighter than rip-rap and stand at a still steeper slope when wet and compacted. But it would be a very risky thing to design a sea wall for a cinder filling and then be unable to procure the filling.

When Christopher Street section was being filled in in the rear of the wall, the mud wave created by the filling was of such proportions that it curled over and fell into a portion of West Street.

MR. WAIT.—That rip-rap filling is calculated to make a prism from the solid foundation up practically to the top of the piles. That is virtually a dam on the inside, and it resists the thrust?

THE AUTHOR.—No, the rip-rap must be considered as an element producing pressure. To illustrate this fact, I would like to ask what would happen to this rip-rap embankment if the wall were suddenly removed? The rip-rap does not remove the thrust from the wall, but it enables us to use in our calculations for pressure a narrower prism of maximum thrust.

MR. WAIT.—I think I disagree with the gentleman. I should think that as far as the pressure below the foot of the wall is concerned, if the rip-rap stayed against the piles, that virtually the thrust of the mud would be perpendicular to the line of the wall and that the wall or dam, as I should call it, would take up a large portion of it.

THE AUTHOR.—You are talking about the foundation below the wall proper. We design a bulkhead or sea wall to resist the pressure from the rear produced by the filling and an assumed surcharge of 1 000 lb. per square foot on the street surface, and design a foundation to properly carry or support this wall.

MR. WAIT.—I would say further that I do not think the Government would furnish the price of a rip-rap dam, or prism so called, on the inside of a retaining wall or sea wall.

MR. THOMPSON.—In the matter of the pressure brought about by mud waves, I think we had a very good example in The Bronx a year or two ago, in the matter of the abutments to the bridge in Baychester. The filling back of the abutments was piled in promiscuously and created a mud wave which came against the abutment and foundation, and my recollection is, that the abutment was moved by it nearly 3 ft. The masonry was well built and held together very fairly, but the pressure was such that it pushed the piles over, and the abutment itself a number of feet toward the railroad tracks. The abutment was built for a bridge intended to cross the N. Y., N. H. & H. R. R. tracks. There was, as I recall it, no brace of any kind between the abutments to keep the piles or abutments from moving; no arching or even timber to prevent it. The result was, that the entire abutment had to be taken down and rebuilt. This work was done under the Department of Public Works.

THE AUTHOR.—I would like to ask Mr. Wait if there was anything in the nature of a relieving platform behind that Government wall. I do not understand the construction as he has described it.

MR. WAIT.—I will say that there was. In the rear it was stepped; a platform ran out which rested upon the platform piles. The platform was about 6 feet wide.

THE AUTHOR.—That is one of the weak points of that wall. What was the height of the wall, Mr. Wait?

MR. WAIT.—One was 11 and the other 15 ft.

WILLIAM J. DUNCAN, Member of the Society.—I would like to ask Mr. Wait if there was anything to hold the wall?

MR. WAIT.—Yes, they drove additional piles straight down between the grillage timbers at the toe of the wall, put a cross piece on top of those piles and shimmed it up. (Explained on board.)

MR. DUNCAN.—I have had to do with a somewhat similar case: it was that of an iron bridge supported on masonry piers with pile trestle at each end. The masonry piers were carried by piles 60 to 70 ft. long driven into soft mud most of the distance. The trestle was being filled in when the pier started to move out into the river, as the piles had little stiffness longitudinally of the bridge. In order to hold the pier, piles were driven back some distance from the pier, where the ground was firm, and rods were put in from the foot of pier to these piles. This device held the pier and the filling of trestle was completed without further trouble.

THE AUTHOR.—Was that wall wrecked, Mr. Wait?

MR. WAIT.—I haven't seen the wall. I am the attorney in the case. What I know about it is from expert witnesses. The whole length of the wall was 700 or 800 ft.

THE AUTHOR.—Do I understand that you do not know whether it was wrecked or not?

MR. WAIT.—Wrecked to this extent, that it went out on one side, from 8 to 10 inches. They never filled in behind it except about 3 ft. with sand filling. When it began to go, they quit. Our contention is, we erected the structure according to their plans, according to their design, and we are not responsible whether it stands or falls.

MR. MARTIN.—Do I understand you to say, Mr. Wait, that it is "the engineer's fault"?

MARTIN J. BROWNE, Member of the Society.—The contractor having accepted the plan, agreed to build the wall under the specification and in every way taking it upon himself to do that work according to the way in which it was planned, is he not responsible?

MR. WAIT.—The case of the Brooklyn Reservoir is the leading case on that point. Other cases have followed that. One is the case of the McClintick Flint Rock Company, where a cellar was to be made water-tight and he agreed to do it according to the specifications of the engineer. Those two cases and a number of other

cases have held that where the contractor conforms to the specifications and plans prepared by the engineer, and uses material approved by the engineer and he does good work and uses good materials, that although the contract says that the reservoir shall be water-tight or that the cellar bottom shall be dry the contractor is not responsible for leaks. He does not adopt the plans of the engineer and warrant them. Warranty is the word; guaranty is an obligation of one man to assume the debt of another; a warranty is an undertaking on the part of the contractor to secure or maintain certain results or to make good. I think that answers the gentleman. The decisions are against him.

MR. BROWNE.—Is it not a fact that the contractor has got to make his objections against the plans and specifications and contract drawings before he finds that they are faulty by actual test. Must he not make his objections before beginning work?

MR. WAIT.—The decisions do not hold so. The decision says this—that a warranty will not be implied, but it must be expressed, and it must be expressed in such unequivocal terms that there can be no question about it.

THE AUTHOR.—I would like to respectfully protest against the use of the term "dam" in Mr. Wait's discussion. No portion of a *bulkhead* wall is ever constructed as a dam unless it is to be used as such. Most emphatically, at any rate, must I insist that it would be unwise to attempt to make our bulkhead wall a dam. On the contrary, the preservation of timber demands that the construction shall encourage the action of the tide in the rear of the wall. This has all been amply set forth in the paper.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

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THE ENGINEER'S FAULT.

BY JOHN C. WAIT, *M. C. E., LL. B., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
SAMUEL C. THOMPSON, GEORGE W. TILLSON, WM. FOULKE JOHNES,
DENNIS FARRELL, WILLIAM W. BRUSH, LAZARUS WHITE,
RIENZI H. BETHEL, GEORGE HALLETT CLARK,
WALTER G. ELIOT, SIDNEY W. HOAG,
JR., MAX L. BLUM AND
THE AUTHOR.

I have divided my lecture into three general divisions:

I.—The Engineer's Status.

II.—Projection, Authorization and Construction of Public Improvements.

III.—Settlement of Account between Parties, including Suit and Duties as a Witness.

I.—THE ENGINEER'S STATUS.

"The Engineer's Fault" is perhaps to the engineering profession a significant title and one which might be enlarged upon to the unhappiness of engineers if the purpose of the author were to take up and to point out the faults of individual engineers, or if the faults of any particular engineer were brought directly to his attention, and especially in a public address. This is not the intention, and whatever may be said this evening should be taken to apply to nobody in particular, but to everybody in general.

Some things, no doubt, engineers are responsible for—many of the good and useful things of this world; but they will hardly claim

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to be paragons of perfection, and I believe will confess that they have faults. In this address I desire to point out not only faults for which the engineer is responsible, but faults with which he is charged, whether responsible or not, and particularly those faults which arise from the engineer's practice in conjunction with the departments of the municipality, and more particularly with the law department.

This evening I am presenting some observations and points which have arisen during my employment by The City of New York, and which seem to me might be of interest to the members of this Society and perhaps of immediate benefit and profit to all, if considered in the spirit of propriety in which they are presented. If they are pointed or bring up matters which are or have been the subject of newspaper notoriety, or if they contain allusions to matters which cause sensitiveness on the part of any members, I wish it distinctly understood that they are not mentioned with any purpose of giving unhappiness or calling attention to the shortcomings or failures of any officers of The City of New York or any of its departments or bureaus.

Members of the engineering profession have always been at fault. They have been great mistake makers and they always will be. It is the men who attempt who fail. The engineer is constantly grappling with great forces. He is usually opposed to Nature. It is *his ingenuity* against *her forces*. Here he seeks to resist her attacks, there to harness her agencies. His are great efforts, to conquer great difficulties, to overcome obstacles and to put to use the wastes of our Mother Earth. Should he make mistakes, shall he be charged with fault?

Was it Smeaton's fault that the Eddystone Light-house fell; was it Hudson's fault that our river did not afford a northeast passage; was it Lindenthal's fault that the river is not bridged; was it Perry's fault that he did not reach the North Pole, and is it the engineer's fault that the English Channel is not tunneled, that Panama is not canaled, or that Pompeii has not been excavated?

Engineers make every effort to avoid mistakes, to meet every occasion that can arise, and to keep themselves above the suspicion of being at fault. To this end they not only seek to acquire what is strictly necessary to their profession, but they have invaded many

other fields, that of the physician in sanitary work, the chemist in mining and milling, the architect in industrial design, the lawyer in the preparation of deeds, contracts and in promoting enterprises.

Some of our engineers are masters of the essentials of half a dozen professions, and they practice them, too. They are eternally in search of the fountain of wisdom, and this effort of members reminds one of the search of Ponce de Leon for the Fountain of Youth.

The engineer reminds one of the Japanese explorer who became aged, like de Leon, and sought the Fountain of Youth. To this end he took up his residence at the edge of a dense forest, where he lived with his wife. It was his habit to make excursions into the forest to study nature and to enjoy nature's creations. One day he followed a tiny rivulet and, coming to a spring, knelt down for a drink and then rested a few moments. Presently he stooped to drink again, when another's face was reflected in the water as if a stranger was looking over his shoulder. He looked behind and about him, but no one was there. He again stooped to drink and the face was still there, but a closer study of it revealed to him the face of his manhood, full, firm and joyous. He had at last discovered the Fountain of Youth.

In his joy he hastened to his life's companion, but she knew him not until he explained, when they both hurried to the fountain of perpetual youth. The wife arrived quite breathless and exhausted from the exertion of keeping up with her youthful consort, and, womanlike, prayed a little delay to recover her breath and to prepare for the momentous occasion. It would not do for a youthful girl to be wearing the weeds of old age. She should have youthful raiment, a fig leaf and some roses; so the gallant husband hastened away to find her a leaf and some flowers. After a while he returned to the spring, but the wife was not there, though part of her garments. "Oh," thought the sage, "she has drank and, like a buxom lass, has hidden in the thicket to coquet with me; I will find her." He searched the spring and the adjacent brush, but without avail, and with deep sorrow started for home. He had not gone far when in the thicket he heard a weird cry and hastened to it. There he discovered a tiny baby, while beside it was a half shell of a gourd, emptied. Taking the child tenderly in his arms, he walked along the

path until a gleam of sunshine lighted its face, and halting there, traced in it the features of his wife. She had overdrunk at the Fountain of Youth and it had done its work.

Do not expand your profession too broadly lest you spread the gray matter so thin that your work shall suffer. One man's work cannot spread over too many fields. Remember the woman; drink not too deeply.

Some may be inclined to apply this consistently to myself, but in defence I may say that I have never been out of the engineering profession. My practice in the law is chiefly in construction work, public improvements and municipal law, which is Engineering.

I would not be justified in omitting some mention of the engineer's status in his department. The engineer is the mainstay and the back-bone of a department. He ought to be. Each new administration brings new and unfamiliar, if not ignorant, heads of departments. In some departments he is not only the engineer in name and reality, but he is the administrative, the legal and sometimes, I am led to believe, the political adviser of the head of his department. In thus speaking I do not need to except even the Finance Department. The confidence exhibited by Comptrollers in the Engineering Bureau of the Finance Department is, I believe, almost unparalleled, and something to be very proud of. I can speak with almost equal praise of the engineers of the Board of Estimate and Apportionment, and, I think, of the Borough Presidents' offices. The other departments are perhaps equally deserving, but I have not been so cognizant of their influence. It is sometimes annoying to the legal department of the city to have engineers of the Finance Department quote the law upon any subject to Assistant Corporation Counsels. Outside of the joke, the serious aspect of the case is that the engineers are frequently correct.

The wonder is that engineers have not the same persuasion as to their real merit and value in dollars and cents, and that their salaries are not commensurate with their services and the confidence reposed in them. The *engineer's fault* is that he is willing to accept confidence and responsibility in part payment of his services, in lieu of gold. At the end of the year he is likely to complain that it does not pay his house rent and provision bills.

On this subject much might be said, but my question is, whose

fault is it? Is it any one's fault in particular? And I fancy I can hear the rank and file of the Society say that it certainly cannot be charged to us. I quite agree with you that the fault is higher up, when members of our profession who are the heads of important commissions and receive $10,000 to $12,000 per year for only a part of their time, and who, with their associates, assistants and subordinates, have their own expenses paid out of the public treasury, and whose recommendations are law, recommend that the rank and file of their bureaus of competent engineers shall receive salaries of from $1 200 to $1 800 per annum. The fault is apparent.

Personally, I am delighted to see the services of any engineer appreciated and rewarded, but I feel and believe that it should be distributed along down the line and not remain at the head, and members of an honorable profession who place the value of their own services at so high a figure might, it would seem, with good grace, consider that their associates and the rank and file of their employees must live as well.

The fault may be higher up, but why should the rank and file part with their services at half or third price? Do you not yourselves put a price upon your labor and services when you accept and consent to work for laborers' wages? Is not the fault your own, in part at least?

The engineer has not to contend with title and guaranty companies, indemnity companies, corporation companies, collection agencies, patent and trade-mark agencies, like the *Scientific American* and the legal aid societies, which rob the legal profession of large branches of its legitimate practice. So far the practice of engineering is comparatively unimpaired by professional corporations, but I can see in the existence of the testing companies and in the monopolistic manufacturing companies that destructive influence will be wrought to the engineer's *professional* work. Few of you engaged in municipal engineering perhaps realize the effect of these, but their influence is far-reaching and very damaging to professional success, or its existence even, not only to civil engineers, but to the several branches of industrial engineering. This may be charged chiefly to the tendencies of American business methods. The avowed purpose is to eliminate the middleman and the small operator and to deal directly with the purchaser or consumer, and to provide or sell

finished structures or plants erected in place, thus dispensing with professional engineers, lawyers and ministers even. This applies especially to the great bridge companies, the great steel companies, the great electrical manufacturing companies, and generally to combinations for the manufacture of pumping and refrigerating plants, railroad motive power, rolling stock and others too numerous to mention.

Having a monopoly of the raw materials and of the finished product, these great corporations have it within their power to become worse than the slave-holders of 1860, as employers. Being a law unto themselves, they are invulnerable to the attacks of lawyers, exercising the whip hand over contractors and consumers who dare to litigate disputed claims. Being invulnerable to attack, they have little fear of litigation and no cause for remorse. There is, therefore, less need for the prayers of the saintly.

The result of all this is that our engineers are becoming specialists of the factories and shops and operators, the employees of erectors and foundation specialists, or they remain draftsmen and waged employees of the great manufacturing concerns. Our lawyers are daily becoming more and more counsellors instead of advocates, and our ministers missionaries instead of pastors of flocks. Is the picture too strong, too much light and shade? Are the colors too bright? Is it the fault of the few men—engineers—more ambitious to serve Mammon than their fellowmen?

II.—Projection, Authorization and Construction of Public Improvements.

Public improvements of a municipality are created and accomplished by successive stages known and described in different circles by different terms, some more specific than others. I have adopted terms and subdivisions for this lecture which I believe are familiar in the engineering profession.

Public improvements are first projected or promoted, sometimes by engineers and sometimes by politicians, real estate men or by public-spirited citizens or organizations of citizens. Secondly come the preliminaries or preparations for such work, which include suitable legislation by the Legislature, the Municipal Assembly, Board of Estimate and Apportionment or head of department neces-

sary to authorize the improvement, including the appropriation. Thirdly, come the operations preliminary to construction, which are not only prosecuted by the engineering bureau, but by the law department, in instituting and completing the necessary condemnation proceedings. Fourthly, the necessary preliminaries to a contract obligation, *viz.*, the advertisement, opening of bids and award of contract, also the preparation of the contract and specifications and the establishment of a standard of comparison.

Fifthly, the contract, which should include many essentials and some non-essentials to the successful undertaking and erection and completion of the public improvement, most important of which are a precise description of the work to be undertaken and numerous conditions precedent and requirements as to the erection and completion. These include the time of performance, liquidated damages for delay or bonus for early completion, provisions for payment, indemnity clauses, clauses required by legislative enactments, provisions for conditions anticipated, arbitration clauses and provisions to avoid accident, clauses to limit sub-letting and assignment, and others depending upon the particular work or the conditions presented; the specifications describing the work, the surety for the performance by the contractor, etc.

The specifications are peculiarly within the province of the engineer, and I will not take time here to discuss them, except to suggest to engineers that the specifications should not repeat the terms of the contract as above enumerated; that the best practice requires that the specifications should define the work and materials comprising the structure.

Projection.—The projecting of public enterprises is something that engineers have little to do with generally. The initial steps are usually mushroom-like in their creation, and the result of conditions. In municipal work, probably, the real estate agents and owners initiate the greater number. They, with the aid of politicians, secure petitions and legislation recommending or authorizing public projects. Sometimes such efforts result in a struggle between conflicting interests. This struggle varies from that between neighbors as to which man's house shall have the street lamp, to such struggles as for many years deferred the construction of our subway, the Panama Canal and, locally, the Bronx railways. It

may be a struggle for the profits of construction or of operation; it may be railroad interests against ferry or shipping interests; or it may be a struggle between several transportation interests, as that now going on before the Rapid Transit Commission, during which time the *public* suffer.

It is when a happy combination of financial, public, personal and relationship interests—"a community of interests"—can be effected or compromised, as existed in the city's latest and largest undertaking, that results are at last realized and the public gets long-promised relief.

These conditions and manipulations are not, with a few exceptions, the work of the engineer. Sometimes commissioners are appointed to investigate a probable source of water supply, or possible routes of transportation, but they are exceptional. We will not, therefore, dwell upon the projection of work. Not being the work of the engineer, he is not chargeable with fault.

Authorization.—The authorization of work usually rests with the law-giving power of a government, either with Congress, the Legislature, the Board of Aldermen, or pursuant to such authority as may be contained in the City's Constitution—the Charter—by the Board of Estimate and Apportionment and the local boards. With these the members of this Society have little to do except to make preliminary surveys and an estimate of the cost of the improvement. I will not, therefore, dwell upon this subdivision.

Operations Preliminary to Construction.—This requires the combined labors of the engineering and law department and includes preliminary surveys, the defining and recording of property required for the improvement and of the property rights, incorporeal as well as corporeal, that will be appropriated or destroyed or diminished. Upon this subject the author has prepared a 700-page volume, to which he refers. It is here that the lawyer and the engineer should work together and should express and exchange their respective views. They need the assistance of each other in presenting and explaining the law of property rights and the laws of Nature, and their relations one to the other; the results that may be anticipated from the acts of Nature and the interpretation of those acts by our courts as affecting rights of neighbors *in rem* and *in personam*.

Preliminaries to Contract.—It is now that the engineer takes

matters in hand. The preparation of the estimate of quantities requires extended surveys, borings, test-pits and examinations as to grades, conditions past, present and future, the discovery of Nature's hidden secrets, of subterranean and submarine sands, faults and ledges. It requires a study of materials, processes and designs and the final or conclusive adoption of those which are most suitable. It requires that the improvement and its parts and members and materials, and the processes by which results are to be attained, be specifically described. It requires that a standard of comparison be established, by which bids may be submitted and compared. This should precede the drafting of the contract, in order that its terms and conditions may be applied to the subject matter thereof. In this work great care should be exercised, and when done it should receive the unqualified endorsement of the engineer. It should be a careful statement of what has been done, what was discovered, and of the results obtained.

A failure to do these things is most prolific of law suits and litigation, and occasions much controversy between engineers and contractors, especially when the preliminary investigation made by the engineer is subsequently disowned by him. I refer to the engineer's investigation to determine the character of the sub-stratum and its bearing capacity for structures, which includes soundings, borings, test-pits and other operations adopted by the engineer to ascertain the character of excavations or of sub-stratum and the expense of excavating the same, or its capacity to sustain loads or their impenetrability to water or other liquids. Engineers spend months in making investigations of this character and then they disclaim any responsibility for the results thereof and deny that they know anything whatever about the conditions prevailing at the site, but they do expect or require a contractor in a few days, or at most a couple of weeks, to conduct experiments and make such investigations as will enable him to stake his entire fortune upon them. Is not this the engineer's fault?

Who is best able to assume the risks or to insure the stability of work erected upon such a site? The municipality which has conducted most extended investigation, or the contractor who has made none? Examples are indeed numerous. They have occurred on our New Croton Dam, dry-docks, in the improvements at Annapolis, on the Erie Canal, and in nearly all government work.

I had occasion a short time ago to read a contract and specifications as counsel and to pass upon it. The specifications recited that the City Engineer had investigated the sub-strata and knew it to be substantially as represented; that if it were not so the city would make good the contractor's loss and any damages sustained. This is extraordinary. This is the first case that has ever come under my observation.

It is truly the most economical practice. It brings the bids to a standard of comparison. It gives to the City or Government the benefit and advantage of all the money it has expended in preliminary investigation. It promotes engineering practice and saves contractors from disaster and ruin.

No one thing contributes more to the disaffection between contractors and engineers and to righteous indignation of the former than the disavowal of results of the engineer's investigations.

Is it the engineer's fault? The clause is no doubt the creation of the Law Department, but, on the other hand, it is counselled by the engineer and no doubt is a safeguard to his professional reputation, and an assurance which most engineers are very willing to adopt to save themselves from criticism and discharge in case of reckless or indifferent work or insufficient care in making the investigation.

I have sometimes wondered if such safeguard stipulation were kept in use so that an engineer might misrepresent the condition of things, giving to favorite contractors the true condition of affairs, thus enabling him to more successfully compete and to secure the award and contract. How easily this could be done every one in this Society knows.

The abolition of this clause, this disclaimer of an engineer's professional work, is one thing that I had hoped to correct before leaving the Corporation Counsel's office. I am fully convinced that it is wrongful and against the interests of all parties concerned, except perhaps the politician and his favorite contractor. It will be very difficult to do this, because anything that affords personal protection to an engineer and safeguards dire results from his errors and neglect will be difficult to eliminate, however unjust to the contractor or expensive to the municipality. Moreover, the Law Department *feels a* substantial judgment against the City, when it is

not cognizant of the enormous saving to the City resulting from intelligent bids for public works. With the engineer and the Law Department in favor of the clause, there is little hope for the public treasury or the contractor.

Under the topic of "specifications and plans" there is one subject which I feel it proper to discuss and which may properly come under the subject of the "engineer's fault" as against the "contractor's fault." I now refer to insufficient plans and specifications as against defective workmanship. The engineer, in his desire to keep up with the rapid industrial progress now developing and to adopt every new and improved device of construction and every improved class of material, sometimes permits his zeal to exceed his discretion. This occurs when the engineer adopts materials or processes of construction without a thorough investigation and test of their qualities and their durability.

I do not think that the engineering profession is as culpable in this particular as are architects as a class, but misfortunes do occur in consequence of the failure of the engineer to take proper and reasonable precautions. This results in experimentation on the part of the engineer, and usually at the expense of the contractor. The engineer, not having the power to use or appropriate the funds of the municipality for purposes of experimentation, and not being, therefore, authorized to certify work that has been done and afterwards condemned, the contractor is left to foot the bill without remuneration from the municipality.

A like situation arises where the plans or designs of the engineer are insufficient and where unwarranted weaknesses develop in the structure, or even where the ultimate completion of the public improvement is prevented.

If the site of the proposed improvement has not been sufficiently examined and developed to reveal the conditions existing and the character of the sub-strata, as for foundations, and the structure fails, then the question arises whether the failure of the structure is due to defective plans or to insufficient investigation in the preliminary work. Plans designed for conditions that do not prevail are insufficient for the location where the structure is ordered built, though they might be entirely sufficient at some other site, and an engineer may reasonably be charged with defective designs for a

structure to be built upon an insecure site, as well as for the failure to make proper and sufficient investigation to determine the character of the sub-strata upon which the structure is to rest.

If a structure fail from inherent defects in design, and the builder is by his contract required to follow the engineer's plans and specifications, it would be manifestly unjust to hold the builder responsible for the failure, unless, indeed, the engineer seeks to make the builder an insurer of his professional skill and designs, thus confessing the superiority of the layman over the professional engineer or architect.

This is the effect of some specifications by architects, and in some instances of engineers. It may be excused in cases where the builder is a specialist in his line, as the American Bridge Company in steel structures, the National Pump Company in hydraulic machinery, or the Westinghouse and General Electric Companies in electrical plants; but in such cases, were it not better for engineers to designate the site or place for the works, the capacity, efficiency or duty of the plant or structure as the work it shall perform or the loads it shall carry, and leave the specifications and plans to the bidder, being careful to describe explicitly the tests of efficiency to be required? Such a practice would relieve the engineer from the charge of adopting certain manufacturers' plans and specifications and features, and of making an effort to stifle competition by limiting the bids to one or a few bidders. The courts are keenly alive to this situation and they are likely to hold that a construction company is not an insurance company and that however many so-called *guarantees*—more properly called *warranties*—the engineer injects into his specification, such as to warrant the cellar, sewer or reservoir to be water-tight, or the structure to carry certain loads, or that the structure shall be stable and resist the action of the winds, waves, tides and floods—they do not constitute a *warranty* where the contract specifies the dimensions, design and members of the structure and the character of materials, the process of mixing and placing. A warranty by a builder as to results implies that he shall have some say as to the design and methods of erection.

Of this practice of adopting plans and specifications of specialists, who are the manufacturers of special designs or character of structures, machines or plants, especially in municipal practice, too

much cannot be said in condemnation. It leads to personal controversy and litigation. The efforts of bridge companies, first one and then another, to control the erection of our great bridges, to the exclusion of competitors, has resulted in not only unenviable newspaper notoriety, but in dissensions in our profession, great delay in our public improvements and personal bitterness detrimental to the profession. The effort of certain fire-proofing interests allied to strong political factors to control the Building Department; the attempt to specify certain patented sewer pipes; certain acid or basic steel; a certain style of library stacks; marble or granite from certain quarries; certain kinds of pavement; certain brands of cement, plaster or even of crushed stone and sand from a certain locality; certain types of engines, electric generators, refrigerating, steam heating and laundry plants; certain crushing plants, road rollers, sprinklers, etc., have aroused the indignation of competing trade and have been enjoined by our courts.

It may be accepted that attempts to favor particular manufacturers will always arouse controversy in competitors, and that every device, plant and class of materials will have its advocates, and that trade will be aggressive and unscrupulous in presenting its wares. Though the engineer justify his preference, by proving the subject of his choice better, stronger and more efficient, he cannot justify illegal acts or illegal practices. He should meet the situation by honest and lawful methods, thus saving his own self-respect and keeping within the law.

The results desired may be secured by specifying conditions and tests that must be met, thus encouraging manufacturers to meet the conditions by improving their goods, machines and plants and creating healthy progress in the industrial arts. By all means, the engineer should avoid the imputation of being owned by any particular interests, local or outside. The politician's policy of local patronage is a dangerous one when the charter and ordinances forbid it. This situation presents another one for a diplomat-engineer.

If the local manufacturer or builder, having the advantages of proximity to the work, knowledge of conditions, acquaintance with the labor and material market, and a thousand other things, cannot compete with the outsider, then something is the matter with the local bidder. He needs no inside information nor favoritism; it is

more likely that some one other than the contractor is being benefited.

Time Limit.—Another element of this subdivision is that of the period of time fixed for the construction and completion of the improvement. This is another thing prolific of complaint, controversy and litigation, especially when a substantial sum is named as a penalty or liquidated damages for delay.

Probably no one thing is made the subject of greater abuse in governmental work, and especially right here in New York. It has become so flagrant that the courts almost uniformly refuse to enforce stringent contract clauses for liquidated damages, and the time limit of a contract with the city has become virtually "a dead letter." Whether from intrigue and connivance with favorite contractors, proteges or politicians, from lack of practical experience and knowledge of engineers and architects, or from sheer negligence, I do not need to inquire, but I do declare that something should be done to rectify this evil. Without doubt many things contribute to the determination of this period of time. The engineer does not always have the final determination of it. His recommendations are sometimes ignored and the time arbitrarily fixed by somebody else. The effect, however, is apparent. Outside bidders, not assured that the time limit will not be enforced, or that they may continue their work into a favorable season or over two seasons, cannot compete with contractors who have that assurance or who feel that they will get indulgences. If the time be short, the assured gets the contract, and the more conservative and careful bidder, the business man, loses to the gambler or politician, the *assured.*

This, however, is but one phase of the *time limit,* when not enforced. It is the City and the Public that get the burden and the disagreeable end of the bargain. Was there ever such intolerable delay experienced as has characterized the Elm Street improvement, where the property owners, from one end to the other, have been nearly bankrupted by the tying up of their property for more than eight years? What an immediate crying need was declared for this thoroughfare in 1894 or 1895! In 1899 a committee representing these taxpayers came to my office to get me to take up the matter and get relief from a most burdensome condition. Six years later, only very recently, have they secured ingress and egress over this thoroughfare. Was this the engineer's fault? Nearly ten

years' deprival of their property, besides being assessed heavily for the public improvements. Talk about Roman oppression! You do not need to read Roman history.

As aggravating instances occurred in our Rapid Transit construction, which contributed so much to the Elm Street condition. The Subway contract provided that openings of streets should continue only for thirty days, except by consent of the abutting owners. Yet those Subway execavations were opened and maintained open for periods ranging from six months to twenty months, and the streets encumbered for even longer periods, to the destruction of business and property interests, to say nothing of inconvenience. That this was necessary may be gravely doubted. It was avoided in some places where influence would not tolerate it. It is not found necessary in lower Broadway, as now being constructed.

Was it not the engineer's fault? Was it to anybody's great benefit, was that benefit commensurate with the damage, and can it in any way be justified?

These are two of many examples. We have the Hall of Records, the Blackwell's Island Bridge, the new East River Bridge and its approaches, including Delancey Street, the three great reservoirs, that are each years past the times set for their completion, some of them at a cost greatly exceeding the original contract price. Had other bidders known they could have taken their own time for the works, how much cheaper would they have been undertaken?

Nobody knows better than the author that part of the delay to some of these works has been due to conditions not within the control of the engineer or the contractor, but a great deal of it *is wholly inexcusable* and the result of the grossest indulgence.

The consequences of this are far-reaching. It is not only the inconvenience to the public, the interruption of traffic, the destruction of the business and property interests of abutting owners, but it clouds the development and progress of the whole community to be benefited by a large public improvement and defers a far-reaching benefit for years, while during that time the property owners of the whole district are deprived of the use of their money collected in taxes or assessments.

Nor is this all. If, as is frequently the case, the public work has been awarded to several contractors and the completion of some

parts of the work depends upon that of others, then some contractors suffer very great loss, to the favoring of others. The New East River Bridge affords a mischievous example of this, where the work of the contractors for the Anchorage was suspended for five and one-half years, during which time the time limits of other contractors were several times extended on no apparent excuse, but as indulgences. During this time the plant and temporary works of the anchorage contractor had deteriorated and had to be renewed, the price of materials and labor had greatly increased, and several of the engineers and contractors, their superintendents and foremen, were dead, and the prospective profits were multiplied into losses. Were the engineers who recommended the extensions at fault? Will the City make good such losses? Not if it can avoid it.

This is an instance of the evil results of dividing the responsibility of erecting and completing a public building or structure among several contractors. It is a practice usually attended with delay, shifted responsibility and subsequent controversy.

Complete Work.—Another feature to be observed, essential to the success of a public improvement, is to have the specifications and plans describe and show a complete structure. A failure to do this occasions delay and brings on all the trouble and conflict arising from having several contractors on the job. Nor is this all; it leads to the unhappy conditions that exist on so many of the great public works at present. Thus, great bridges are planned; they are erected after years of delay, and then no thoroughfares or means of transportation are provided by which to convey the traffic. Great piers and abutments are erected, to stand for years awaiting the superstructure. Park property is acquired; buildings and structures are torn down and the land allowed to lie unimproved for years thereafter. Great reservoirs are planned and started under contract without provision for auxiliary structures, which are built long after, when they might have been started contemporaneously with the principal structures. These conditions are not usually the fault of the engineer, but the fault of the power that authorized the work and made appropriation therefor; or, rather, that fails to authorize and appropriate. However, the engineer should exercise his persuasion to have the contract for a complete work.

A further reason why the specifications should include all the

work required to erect and operate a structure is that the Charter and almost every act of the Legislature limits the additional work that may be done without advertisement and public letting to $1,000. This being so, any work omitted may bring other and new contractors upon the work to breed trouble and to divide the responsibility. Sometimes this limitation is ignored, as has been done under the last two administrations of the City Government, when changes and alterations and additions were made "*contra expressam legem.*"

The extent to which this has been carried of late is the extreme. Additions and excess work have been ordered on the large bridges in values of hundreds of thousands of dollars, and on our water-supply reservoirs in amounts of millions of dollars. This practice is wholly unwarranted and is certain to lead to mischief. That it has been done may not be the engineer's fault, but it could have been avoided, at least in the greater part.

Liquidated Damages.—There is a popular notion that liquidated damages cannot be assessed for delay; and that is pretty nearly correct with a municipal corporation. The right to retain a sum as liquidated damages does not, however, as is supposed, depend in any way upon the bonus offered or upon the fact that any bonus was offered. The difficulty in recovering liquidated damages arises from the trouble of showing that the city has suffered actual damages or anything more than inconvenience. The policy of the law forbids the recovery of any damages but the actual damages.

Award of Contract.—Following the advertisement is the award, which should not be made precipitately. An offer, which a bid is, when accepted unconditionally constitutes a contract; hence the necessity for deliberate action when accepting a bid. The public officer should be assured that all the ceremonies required by law have been performed and the letter of the law complied with, also that the appropriation is sufficient, for the binding effect of all contracts with the city, except those to be paid in whole or in part by assessment, is postponed until the Comptroller certifies that the appropriation is sufficient to meet the expense thereof.

Formal Contract.—Following the award is the execution of the formal contract, containing many clauses. I cannot discuss them all, but will select those about which there is and will be difficulty.

Many clauses are required to be inserted by the ordinances, the

Charter and Legislature. Of these there were several labor law clauses—one as to hours of labor, another as to the payment of the prevailing rate, one as to the employment of citizens only, one as to using stone cut within the limits of the State. All are now declared illegal and unconstitutional, after eight years of folly on the part of city officials, intolerant insolence on the part of labor leaders, the usual losses and damages to contractors, and the wicked waste of public funds. There was never any doubt but that the law was unconstitutional. Every layman contractor felt it.

The first opinion I wrote upon entering the Corporation Counsel's office, in 1900, declared the labor law unconstitutional, and the opinion was backed up by a well-prepared digest of decisions to support it. It brought me my first lesson in municipal policy—the opinion was quietly returned to me with the note, "This office is committed to the labor law; opinions should be prepared and submitted accordingly." When the Court of Appeals declared the labor law unconstitutional, I had the satisfaction of seeing it based upon the grounds of *my first opinion.* The decision of this court was not enough. Only last spring the contractors of the city were treated to another hold-up and many contracts were *abrogated, even,* to satiate this bandit of walking delegates, for alleged violation of the eight-hour law, and this after the Supreme Court, sitting in Brooklyn, had declared the eight-hour law unconstitutional. Besides this, contracts were made under the Low administration granting to contractors having large works with the city prices in excess of those bid at public letting, in consideration of the contractors complying with the eight-hour law, by which large sums of money are now being disbursed, though the law is unconstitutional. Be it to the credit of Brooklyn that its Borough President and its Engineer were the first to recognize the injustice of this law and to unequivocally declare themselves in the belief that it was unconstitutional and iniquitous, and to act accordingly.

Assignments.—Another clause required to be inserted in our contracts is that prescribed by Section 444, Laws 1897. This act forbids the assignment of any contract or of any money earned or unearned under public contract, without the consent of public officers, etc. It is as unreasonable as the labor law. It was first held to forbid the assignment by a contractor of moneys earned. The idea of denying

one's right to dispose of what is his own, or of his power to pay his just debts with his just claims! It took a creditor's action to test the law and to dispose of it. The courts, in their charity to the Legislature, held that the law was only intended to prevent the subletting of work to irresponsible or incompetent contractors, and to make the public official the judge of their responsibility and competence to undertake and do the work.

Other clauses are those requiring the placing of lights and guards; that the contractor shall indemnify the city from accidents; that notice shall be given to gas, electric, water and transportation companies before excavating around their lines; that moneys may be retained to satisfy claims of laborers and materials under the lien laws; that the contract shall not be binding until the Comptroller shall certify, and other really quite essential clauses.

All these clauses are inserted in the language of the act or ordinance which requires them to be inserted, and many times have I been required to revise and recast contracts (and at no small amount of labor) that have been remodeled after the ideas and ideals of members of this Society, who, being ambitious, enterprising and progressive and having decided views of their own, have sought to improve upon the language of the city contracts and to make them express what is really meant.

Doubtless many of you have wondered at the name of the advertisement, which is characterized as *Proposals for Bids or Estimates.* It should be called the Invitation to Bidders. The bid or estimate should be called the bid or proposal. There are many other misnomers. These come from using the language of the City ordinances, and it would not be safe to change them. Hence the disputes between the engineers and the Law Department. In the same way the language of contract clauses, as those of arbitration, liquidated damage and dismissal of the contractor, have been taken from court decisions in which the language has been defined and applied, and which construction the courts are reasonably bound to follow.

Ordinances.—These matters recall that three years ago I prepared and submitted to the Board of Aldermen a copy of ordinances correcting this misapplication of terms. They *were* not, and so far as I know *have not been* passed, and it may be interesting to

know that all the boroughs of this city are advertising public works and awarding contracts under ordinances applicable to Manhattan only, and that our Board of Aldermen is acting in contempt of the Legislature of the State in failing, neglecting, and, *I think I can say,* in *refusing* to pass general ordinances for the whole city, governing contracts for supplies and public improvements. The Supreme Court would, in my opinion, be justified in granting a mandamus requiring the Board of Aldermen to pass such ordinances and thus securing our contracts and assessments from attack for having been illegally advertised and awarded. This subject is deserving of the attention of every Borough President and head of department. Will it be the engineer's fault if it continue?

Abandonment Clause.—There are two clauses in our municipal contracts that are iniquitous and of doubtful legality. One in the *abandonment* or *dismissal* clause, which provides that if the city take over and complete the work and there be any surplus of the contract price over the actual cost to the city, that such surplus shall be forfeited to the city, which shall be entitled to retain it, etc. I have no doubt but that our courts would refuse to enforce such a clause. It is inequitable and unjust and would never be favored by our courts. During the *Low* administration it was by my own persuasion directed to be stricken from the city contract, but I notice it is still retained in some cases. On what ground I do not know.

Suspension.—Another clause that is inequitable and unjust is that reserving power to the city to suspend work for an indefinite period. If the city suspend work, can it reasonably ask a contractor to return and complete a structure when the labor and material markets have greatly advanced during the suspension and to the contractor's great loss? I think not. The period of suspension permissible should be fixed at thirty or sixty days, or some limitation made.

Patented Articles.—Another clause inserted pursuant to the charter is that forbidding the purchase of patented articles or pavements. This has been interpreted and applied by the Corporation Counsel's office to suit various conditions. To reconcile the opinions sent out from the office under different administrations would be a difficult matter, or to reconcile them with the decisions of the courts.

In 1902 the Supreme Court held that armored concrete made with expanded metal weighing 85 lb. per sq. ft. could not be specified. It was shown that the patents on expanded metal had expired by limitation, as had also the patents on the machines upon which it was made, but that the requisite expanded metal, being of heavier metal, was made on a larger machine involving certain patented mechanical movements. The Supreme Court, in two cases in 1903, enjoined and prohibited the execution of a contract and specification calling for floor construction employing expanded metal weighing 85 lb. per 100 ft., and forbade the commencement or the prosecution of the work under such specification. Neither of these cases was appealed by the city. The decisions are mischievous and would not, in my opinion, be sustained by the higher courts.

If those decisions are good law and were applied generally to purchases made by the city, they would prevent the purchase of the most ordinary merchandise, including wire nails, boots, sugar and almost every other commodity; yet, notwithstanding that this was pointed out in the argument to the court, the decision was made and the Fire Department enjoined as above described.

Later it was held by the highest court that the city could not purchase a patented bitulithic pavement. Again it was held that the city could not purchase a patented water-meter. Yet, in view of these decisions, it was held by the Law Department of the city that the section of the charter was not violated by the purchase of a particular manufacture of library stack built under no less than five patents, notice of infringement of which was sent to every competing bidder. There you are, and if you cannot discover the dividing line in the preparation of your specifications, then, of course, it is the engineer's fault?

In 1902 a difference of opinion arose between members of the Corporation Counsel's office as to how to meet the requirements of this section of the charter. The position taken by the author and by which patented bridges had been built by the Bridge Department, and by which extensive pumping machinery, the subject of patents, had been purchased, *viz.*, by the city itself paying the royalty to the patentee, was declared by the head of the Law Department to be improper, and a new one adopted for patented pavements and some other articles, the subject of monopoly. The Ap-

pellate Court sustained the method adopted and contracts were provided accordingly for Warren's patent pavement, which the Court of Appeals promptly declared to be not in accordance with the requirements of the Charter. At the present Legislature an attempt was made to amend the section, but without success. How you gentlemen meet the situation now I am not advised, but I mistrust it is met in part by a less strict application of the charter section.

Sometimes it would seem to depend upon the subject matter and the parties in interest. I neglected to state in the case quoted above that it was the Roebling system of floor construction against the Expanded Metal system. Laws are enacted, without doubt, for good and proper purposes, at least ostensibly, as it requires the fair-minded members of the Legislature to pass them, but *it does seem* frequently that they are two edged and sometimes sharpened at both ends, and fall far short of their apparent purpose. This would seem to be true of some of the contract restrictions mentioned. While keeping out objectionable and monopolistic persons and things, they securely intrench those which do get in, lawfully or otherwise, or that secure by favor or exemption relief from them.

Indemnity Clause.—The indemnity clause is a burdensome one to a contractor, notwithstanding the great relief afforded by the casualty insurance companies. It usually provides that the Comptroller may retain such sum as in his opinion shall protect the city from loss. Whether it be a property holder or a person injured, the clause is used as a club to exact money from the contractor. By filing a claim with the Comptroller, no matter whether meritorious or otherwise, the person aggrieved can tie up the contractor's money in amount two to ten times the damage suffered, and without incurring any responsibility whatever, and on the slightest pretext.

An example has arisen in the past few days in my own practice. One of my clients was paving one of the avenues of this city and during the labor agitation was called upon to suspend the work. The pavement had been taken up and the Belgium blocks laid several inches below the finished grade of the asphalt. A teamster driving over this depressed pavement was thrown from the wagon, presumably from its striking a manhole frame, and was killed. His executor having filed a claim with the city for

the loss of the man's life, the Comptroller, under the said contract clause, is withholding contractor's money. In such a case, the contractor has the alternative of either leaving his money with the Comptroller or bonding the claim by an instrument as tightly drawn as the winding of a piece of modern artillery. If he be not made a party to the suit he must depend upon the city or its agents making a proper and vigorous defense and of footing the bill if not successful. Now this is manifestly unjust and especially in the above case.

In the case cited, which is one of many, the contractor is insured in a liability insurance company. By its policy he must notify the company within twenty-four hours of the accident. The accident occurred last August, the city received notice in December, and the contractor gets notice in April when he demands his final payment for his work. Is this as it should be? Whose fault is it?

Patent Rights Infringed.—Another provision of our contracts is that which makes the contractor responsible for all infringement of patents, etc. This might be made very burdensome if enforced in some cases. How can it be justified in view of Section 1554 of the Charter, forbidding the purchase of articles or pavements, the subject of patent right or proprietary ownership? Is the contractor responsible for the infringement of processes or materials specified by the contract, if his contract is illegal, being forbidden by said section?

Employment Contracts.—This contract clause indemnifying the city was embodied in the city's contract of employment for engineers and architects. As is well known, the architects always insert in their contracts a clause declaring that the plans and specifications are the property of the architect. That being so, they must be the creation of the architect and he should be willing to protect the city from suits for their infringing either the copyright or incorporeal right of others. Surely no other reason could prompt the requirement that all drawings should be returned to the architect, except to preserve the right to the incorporeal design embodied and described. Likewise of the engineer.

The anxiety which that one clause aroused and the wire-pulling which was made to have it and other clauses expunged were

interesting and amusing. Committees and delegations from the American Institute of Architects visited the Corporation Counsel to secure its withdrawal and I believe they succeeded. Not one was willing to guaranty the originality of his designs, nor to protect the city from suits for infringements, contained in his own plans. It's different, you know, when these things are applied to the party himself, who may be the author of them. I recall in particular one engineer who raised special objection to this clause. He had been called in as a specialist to design a municipal plant. On being asked if he had himself designed the plant, he declared in the affirmative. The plant had hardly been started when suits for patent infringements were threatened by several patentees and it became apparent that this engineer had employed patent specifications and drawings in the creation of his design and reasonably should have anticipated infringement suits; hence his anxiety to relieve himself from the onerous clause. However, the contract approved by the engineer and the Law Department securely bound the contractor to indemnify the city, and you may believe it put him on the anxious seat. Was this the engineer's fault?

I may add that this idea of architects that they have inherent rights in the designs incorporated in their drawings, after a structure has been erected, should be corrected. A recent decision by our Appellate Division Court has disposed of the question. Building from them has been held a publication of the plans, destroying common law rights in the creation.

It may be gravely doubted if that is what prompts many architects to require a contractor to surrender his plans, specifications, contract and all *written orders even.* It savors very much of the fox and a very probable desire to cover one's tracks and deeds; and to deprive the contractor of his documentary evidence of what has actually been done and taken place. A case recently came to my attention where the architect demanded back all his letters and correspondence as a condition of granting his final certificate. These are faults of the architect. I have never had occasion to attribute them to engineers.

Street Improvements.—Another clause in our contracts for street improvements is that providing for the protection of existing structures, and sometimes for their removal and restoration. There

is not so much question as to the propriety or legal method of doing this when the incumbrance is public and owned by the city as when it is owned and operated under a franchise or by private companies. There has been and is likely to be controversy between the several Borough Presidents and the departments, especially that of water supply and electricity, but the legal difficulties are not great. It is a matter of diplomacy in handling heads of departments and keeping the peace.

It is an annoying problem to municipal engineers to contend with obstructions to municipal improvements, which occupy the streets both above and beneath the surface. Telegraph and telephone poles, elevated railways, street railway tracks, subways, conduits, water, gas and pneumatic pipes, are a constant source of trouble to engineers in charge of street improvements. They have been especially troublesome in Richmond, in The Bronx and in Queens. They have led to considerable irritation in the several departments of the city and between the Corporation Counsel's Office and some of the departments. They have been the source of special trouble between the Borough Presidents and the Water Supply Department. I think that part of this affliction and trouble may be attributed to the engineer's faults.

Streets are primarily for public travel and railways, water companies, telegraph and telephone companies who occupy them are there subject to the paramount right of the public to use the streets for travel. If a public officer is required to change the grade, to pave or to improve a street for public travel, such structures erected and operated under franchises from the city to private parties must give way to such street improvement. It has been customary to require the contractor to protect, maintain and secure such structures during the improvement of such streets. It is very doubtful if such additional cost of a street improvement or of a sewer can be taxed against abutting property as part of the improvement, and it makes an assessment for a public improvement vulnerable to attack by abutting property owners to include such expense in street improvements to be paid for by assessment. Water pipes laid by the city not being paid for by assessment are not subject to such attack, but there has been bitter strife between the departments as to who should pay for the taking up and relaying of water pipes when so

required by a street improvement, each department desiring to save its own appropriation and to put the expense of such excavation and relaying upon the Water Supply Department. Under Corporation Counsel Rives it was held that such expense should be met by the department making the street improvement. Street railways, private water companies, etc., cannot, it is believed, require the city to maintain their tracks during the improvement of the street, and if after due notice such companies do not shore up, protect and preserve their structures, it is submitted that the Borough President may either remove them without replacing or that he may permit such structures to fall into the excavations, care being taken, of course, to protect the lives and limbs of the public. If the companies do not protect their lines and they are damaged or destroyed, it should not be charged to the fault of the engineer.

Changes and Alterations.—The subject of changes and alterations should be mentioned briefly and this seems to be a proper place to take it up. The conditions and necessities of work frequently require changes to be made. When changes are made and they increase the cost of the work to the contractor, he should be compensated for such increased cost, and liberally too. Engineers are generally agreed in that, but frequently they do not allow the additional cost of alterations and they excuse themselves upon the ground that they have granted and given to the contractor many favors, omissions and deductions, which are more than equal to the additional charges imposed upon him. This is not only a mischievous position to take, but it is unwarranted and dangerous. Usually the law will hold that where omissions, favors and deductions have been granted, they can not be offset against increased or additional work required; unless, of course, they are the subject of an express agreement by the contractor. All deductions and omissions should be as much the subject of a written agreement or order as should the additions and extras made.

Written Orders.—Municipal contracts usually provide that no extra or additional work or materials shall be paid for unless authorized in writing and the price thereof agreed upon before the work is undertaken. Where this clause is employed the engineer should not require additional or extra work without giving and granting such an order and it should be his purpose to insist that

such orders be made and filed. Nothing is more annoying or detrimental to the reputation of the engineer than his postponing his determination as to whether in his opinion certain work or materials are extras. To refuse or neglect to determine this question and to hold such accounts for extra work as a threatening club over the heads of contractors is, to say the least, a serious fault, and unfortunately it is a too frequent practice with engineers and architects. It is not necessary that work be completed or that successive monthly estimates be made before the question is determined whether or not the contractor is to receive extra compensation for work that he is doing or has done. Such a course deprives the contractor of the benefit of this clause, as well as the owner, and in most cases it turns out that the engineer has been playing with the contractor without any intention of allowing extra remuneration for such work, which leads to bad feeling and bad repute. It is usually the engineer's fault.

For many years it has been an unwritten law that the Comptroller's office would permit extra or excess work to an amount of 5 per cent. There is no ordinance or law permitting this, the law holding expressly that any work necessary to do or complete or perfect any job, or when any supply is insufficient for any particular purpose, and when the several parts of said work supplied, shall together involve the expenditure of more than $1 000, the same shall be by contract under such regulations concerning it as shall be established by ordinance of the Board of Aldermen, viz., by advertisement and public letting. If the 5% of a contract price exceeds the $1 000, then this practice is in contravention of the charter. Nevertheless in the contracts of 1903 a clause was inserted limiting the aggregate price to be paid for extra work and materials ordered in writing, to an amount not exceeding 5% of the contract price. This was done to meet what appeared to be the exigencies of public work, but there is no authority for it where the said 5% exceeds the sum of $1 000. This is not the engineer's fault, but the fault of the law department.

III.—Settlement of Account between Parties, including Suit and Duties as a Witness.

Engineer an Arbitrator.—This presents the contract clause giving to the engineer or architect the determination of all questions

in relation to said work and the construction thereof and of every question which may arise relative to the execution of this contract on the part of the contractor, and that his estimate and decision shall be final and conclusive and a condition precedent to the right of the contractor to receive any money under this contract, and in some instances making the contractor's recovery subject to the obtaining of the engineer's certificate, and limiting the amount to be paid to the amount certified.

It is generally held that this clause confines the engineer's or architect's determination to questions arising in the work. It does not authorize him to determine the construction of contract clauses, nor the question as to whether there has been a breach of contract, nor the amount of damages resulting therefrom, nor the amount necessary to indemnify the city for losses suffered. It does not give to the engineer the determination of what is extra work or the amount of extra work, unless it be expressly so stipulated.

These clauses are not generally in good favor with the courts. They are regarded as conditions precedent and as clauses stringent and unreasonable. The courts are frequently aroused to jealousy by the feeling that such clauses are used to oust the court of its jurisdiction, and are then frequently declared to be void and of no binding effect. Such cases are where they are drawn too stringent or drastic and thus arouse the feelings of the Court that an injustice has been done to the contractor. In most cases such a clause is held to apply only to the manner, method, means and materials by which the structure is accomplished, and which are within the special knowledge and experience of the engineer or architect, and this would seem to be the most reasonable interpretation. Such a construction is borne out by the clauses which immediately follow and which give to the engineer the power to inspect labor and materials or to reject and accept them and to require that defective work or materials be removed and not used again upon the works.

Engineers as Arbitrators.—Engineers in performing the duties imposed by these clauses should not forget that they are in effect arbitrators between the City and the contractor. I appreciate that it is difficult to conceive a man an arbitrator and in the employ of one party to a contract, and that he is expected to be perfectly fair and unbiased with the contractor; but it is only upon the ground

that he can be and will be fair and equitable that this clause of our contracts can be sustained. If it be shown than an engineer is biased, prejudiced and not judicial in his determinations, then the contract clause should fail and the engineer's determination should be annulled just as much as any award made under any common law arbitration. If the engineer be regarded as the agent of the city, then the contract clause makes the city or its agent a judge of its own case, which is contrary to the elementary principles of our jurisprudence. A contract may not be drawn leaving to one party the determination of questions affecting the rights of the other party, and such contracts are universally held to be invalid.

What has been said should arouse the engineer to the responsibilities of his position. He should feel and understand that he is in a class by himself and not to be rated with political appointees or with clerks, auditors or deputies even. That the engineer should be attentive and conservative of the city's interests, goes without saying. That he is frequently the sole representative of the city upon a piece of work and therefore the only one to protect the city in its helplessness, he should fully understand. He also should appreciate that while the city depends upon the engineer chiefly to protect its rights and treasury, that the contractor is a person with a good pair of eyes and a ravenous appetite. Yet this circumstance does not require that the engineer should be the champion of the city and the aggressor of the contractor. He may be firm, observant, a protector of the city's rights, and yet do fairly by the contractor. He is not reasonably required to gouge the contractor to the profit of the city, nor is he justified in giving way to irritation and revengeful practices, because the contractor is sharp or even unprincipled. An unprincipled contractor, or a thief even, should be assured the protection of just laws.

I do not think that usually engineers sacrifice the respect and confidence of contractors by being firm, determined and fair, and it is my opinion that engineers and even municipal engineers have a reputation to maintain with contractors as well as with heads of departments, not a reputation of favoritism to either side, but a reputation of fair-mindedness, honesty and good judgment. If he does not sustain it, it is his fault.

Litigation.—The public improvement having been projected,

authorized, contracted for and completed, the estimates made and the accounts having been rendered and certified, there still follows the sequel. By this I mean subsequent litigation. In this the engineer who has had charge and who has been frequently a part of the structure itself, is or should be the most important witness. It is upon him the city must depend for protection of its rights and its treasury, and it is here that a very important element of the true value and importance of an engineer is shown. His duties are not limited to the preliminary surveys, preparation of specifications, plans and the contract, and the supervision of the erection of a structure, but he must also be prepared to protect the rights of his employer in what may come after. This, I think, is perhaps the weakest point of engineers, and it comes largely from their failure to appreciate what is required of them in the trial of an action in court or before a referee. The fault lies largely from the want of detailed memoranda of facts, circumstances, measurements and dates. One of the greatest faults of engineers is their failure to date each and every memorandum, estimate or fact recorded. Notwithstanding the training which engineers get in school and in the field, and the frequent and repeated instructions by their employers to date every entry, memorandum or statement made, it is my observation, founded upon a long experience, that engineers, superintendents and foremen do not date their notes.

Testimony.—In order to prove anything before a court or a referee it is essential that the witness should know as to what he testifies, from his actual knowledge, acquired through one or any of his five senses. He can not testify from books kept by timekeepers or bookkeepers, but should and must be *himself* conversant with the actual conditions, facts and circumstances prevailing and about which he seeks to testify. It is necessary, therefore, that he should be present when measurements are made and actually take part if possible; that he himself should note such measurements and should himself note the presence of laborers and mechanics, the number and the actual time employed in doing certain kinds of work, which may subsequently be the subject of litigation. It is not always sufficient that he has seen the work done; that he knows the reasonable value thereof per unit measure; and that he has since measured it. He should *know* himself the actual time spent

or the actual amount of work or the actual cost. In short he should know absolutely within himself whatever he expects to be a witness to. It is a mistake for engineers, foremen and superintendents to leave things to the time-keeper and to the bookkeeper. Personal memoranda from personal observations and measurements are worth very much more to a case than any number of account books.

Public Records.—I appreciate that there is some exception to this rule in the case of public documents and records, but it is far better that the engineer have knowledge within himself and be not dependent upon time-keepers and bookkeepers, who may be in foreign countries or beyond the reach of the court when the case is tried.

Probably in no place is the expression "It is the engineer's fault" more frequently heard than in the law department of the city, as after the trial of some cause in which the city is interested. The lawyer may *plan* and even *direct* litigation and may be primarily responsible for the success of a suit or action at law, but probably he is also the first to excuse himself if defeated or unsuccessful, and while during my experience in engineering circles I do not recall hearing in the office or drafting room the expression "It is the lawyer's fault," I do know what frequently is the unexpressed thought of engineers as to the conduct and handling of cases by the legal profession. Instead of declarations to the effect that it is the lawyer's fault, the engineer usually contributes the failure of the lawyer to his misfortune or weakness and his lack of knowledge of the physical conditions, surrounding circumstances and engineering operations. True, sometimes there are heard words sounding like "dope," "thick," and "what do you suppose he meant," but it is indeed rare that engineers charge failure to the *fault* of the lawyer.

Trial.—The prosecution of a law suit involves first a clear and lucid declaration of the facts in the case. Conclusions, statements of law and arguments should be omitted from the complaint, as they have their place in subsequent proceedings. Facts not known to the party verifying the complaint should be stated only upon information and belief. The answer likewise states facts and should either deny or qualify such allegations of the complaint as are untrue or not fairly and truthfully stated in the complaint. If it

be to the advantage of the defendant to acknowledge and affirm any statements in the complaint, then that should be done, but whatever is not denied will be taken as acknowledged. The trial of the case involves the substantiation of these facts alleged, and this involves a knowledge of what questions may be asked and in what form they should be put, which is strictly the duty of the lawyer. Here, too, in the trial of a case few declarations or presentations of the law are required.

Facts.—From the above it will be seen that preparation of a case for trial and the trial thereof have to do almost exclusively with the facts in the case, and the acquisition and presentation of these facts are what usually wins or loses a case at court. It must be manifest that success in this undertaking depends upon a full and thorough knowledge of the facts of the case, which in construction work is peculiarly within the purview of the engineer. Lawyers therefore depend largely upon engineers to assist them in the collection and presentation of these facts, and therein lies two-thirds if not four-fifths of the battle. If this be true, and I do not think that it can reasonably be denied, it must be conceded that frequently there is more truth than libel in the frequent arraignment of lawyers that the loss of the case was the engineer's fault, meaning thereby the witness's fault.

The chief reasons why engineers do not make successful witnesses are, in my opinion, the lack of thorough understanding between the attorney and engineer; the want of information on the part of the engineer as to the shape in which the facts must be presented to the court, and a lack of self-possession, and the prompt comprehension of the English language by the engineer.

Fault Charged.—No matter what happens, the engineer is more or less likely to be charged with the fault. If the cost exceeds the estimate, then the engineer is charged with short-comings. If floods carry the public improvement away or winds blow it down or earthquakes wrench it from its foundations, or if the mountain slides down upon it, the public is likely to say that the engineer should have foreseen these violences of nature and should have provided against them. In such case the best defense for the engineer to assume is that which was made in a recent case in court where a prisoner was arraigned before the Judge for some

offense and the Judge said: "Prisoner at the bar, have you anything to state in your defense?" The prisoner said: "No, your Honor, I only ask you to deal with me as you would with yourself if you were in my place." I would also recall a wise saw: "The less patience you have the more easily you lose it."

Engineers and Lawyers.—In connection with this I would remind the members of this society that it is of the utmost importance that they should consider the points of view of attorneys and of members of their own profession. Between the legal profession and the engineering profession there is a chasm of differences. From the foundation up, the structural creation of a lawyer and an engineer is totally different. The lawyer's training is founded upon the classics, history, logic, metaphysics and other polite subjects; that of an engineer is founded upon mathematics and the abstract sciences. The one is subtle, clever, trained, bred and schooled as an advocate; the other is arbitrary, determined and fixed in his opinions and absolute in his determinations. To a lawyer a fact is what you may make it; to an engineer a fact is what it is made, not by subtle presentation, but by the laws of nature and by the faculties of reasoning. To the one law means law; to the other law means that which you can convince the court to regard as the law.

Experts.—It is not to be wondered that there should exist a strong antipathy between the engineer and the lawyer, and it finds an expression on the part of both sides in contemptuous expressions, and especially after an advocate has been defeated by the testimony of an expert engineer more carefully schooled and trained in the art of answering questions by his opponent than his own witnesses. It is my opinion that it is the engineer's fault that experts have the awful reputation which the legal profession give to them for the reason that they permit themselves to be biased and be made advocates by the lawyers themselves.

Engineer's Character.—The engineer should fortify himself against attack upon his reputation and character. Generally it is the fault of any man if he be accused of being a partisan or of being owned by certain interests. It should be the care and anxiety of any engineer to be in all his dealings above suspicion and reproach. The fate of DeLesseps in the Panama Canal and of Adams

in the $9,000,000 canal improvement of 1895-98, are instances that should be fresh in the minds of every practicing civil engineer, but it is not necessary to take illustrious examples. In municipal work where the heads of departments are frequently, if not usually, politicians, whose appointments are merely the reward for active work prior to and during election, the engineer's position is particularly precarious. I take my hat off to any engineer who can, successfully, from year to year and through succeeding administrations, hold himself in favor with the heads of his department and at the same time keep himself above reproach. It requires a diplomat to do that, and that it can be done I am fully satisfied, and without sacrificing the self-respect of the engineer. In the Department of Finance we have the example of one engineer holding a responsible position for twenty years without ever, I believe, having been the subject of suspicion. With the Board of Estimate and Apportionment and with the several Borough Presidents we have engineers who have survived several administrations and who are to-day esteemed not only by the present incumbents of their office, but by their predecessors. My own feelings are that these positions are, to say the least, precarious. The members of the engineering profession are universally too poor to be charged with profiting by their positions, and it is and has been the general rule that others than those in the engineering department have profited by the manipulations of public improvements. It has been said, and I believe it, that the state surveyor and engineer who had charge of the canal improvement of 1895 left that office a poor man. I do not think the same could be said of some of his subordinates.

Some of the things for which engineers are found fault with are that they prepare their estimates of quantities, their plans and specifications and their contract to favor certain contractors, be they politicians or favored friends. One of the ways in which this may be done is in the failure to publish the true conditions which prevail at the work as discovered and known to the engineer. If soundings, borings, etc., be made and essential information be given to certain bidders which others do not possess, then those certain bidders have a peculiar and special advantage in estimating and bidding upon the work. If a profile or a description of underlying strata be not strictly correct and it be known to the engineer,

he may thus deprive the municipality of a close and fair competition. If the quantities be not truthfully represented in the estimate and an unbalanced bid be made, the actual quantities as they turn out may make the cost of the work much greater and the profit to the contractor proportional, or the cost of the work might even be less and the profit to the contractor much greater than shown by the actual quantities given to the public.

If materials or work or plant are limited to certain manufacturers, then there is room for suspicion. This doubtless arises from utilizing the experience and services of manufacturers or their representatives in the preparation of the specification with the result that might have been anticipated.

If the engineer so conducts his work and publishes his results that they do not prove true or reasonably correct, then it is his fault that he is the subject of suspicion.

Conclusion.—This is a comprehensive subject, a subject that I wish might be continued by some one else and from another point of view, or by several from different points of view. I would like to see it treated from a historical point of view. Certainly our early engineers made mistakes. Serious mistakes from our point of view. Even the Pyramids were a mistaken waste of materials. What might have been created with the labor and materials wasted in those tombs?

Our greatest physicists and chemists made grave mistakes. The whole theory of phlogiston by Stahl was an error that took many years to upset.

The industrial progress of the world is built upon a graveyard of errors. Engineers need not blush at a rehearsal of their faults, or when accused of having faults. It is to be hoped that they will venture, that they may attempt new ways and means, even at the expense of an occasional failure. Such men are progressive, they work under pressure. What matter if they occasionally let a man out and up through the East River heavenward, or if they drop the City Hall into a sewer trench, it at least shows that something is doing; and worse things have been done than to build bridges where not needed, or to build them where needed, but without the means of utilizing them; and it is better to have built something and to have had it fall, than to have never improved our methods and

materials of construction. Faults belong to those who undertake, to those who do and we may well shoulder the faults, the errors and mistakes with the great results being accomplished. We can well afford to have faults and to know them—for few faults were ever corrected through ignorance of them.

DISCUSSION.

GEORGE W. TILLSON, Member of the Society.—Mr. President, to say just a little that may be in harmony with what has been said by the speaker, asking if it was the engineer's fault, and concerning appearance of the engineer when he comes on the witness stand, I would like to cite several instances where I have been placed in a peculiar position and where I felt if I was not making everybody think I was a fool, it must have been because they had a feeling for me different from what they ought, judging me from what I said on the witness stand. I have been connected with city work for a great many years and have been in court on cases as witness many times, and many times I have been in court and on the witness stand before I knew what the case was I was to testify about. Was that the engineer's fault?

In a case that came up in this city some two or three years ago where I was summoned to the office of a referee to give my testimony, I had never seen the member of the Corporation Counsel's office who was to conduct the examination and I did not know him and he did not know me by sight. Was that the engineer's fault? After one or two hearings I did my best to meet the gentleman and go over the case with him and explain certain things about the case; for I thought then and I still think that there were certain points that I understood better than he, but I never could find him when he had time enough to discuss the question. His answer was: "We will have to do the best we can when we get before the referee." Was that the engineer's fault?

There are many such cases. They are coming up continually and I think the gentleman who read the paper has been very just to the engineers in his paper in referring to the consideration and attention which engineers give their work in comparison with what some of the other officials of the city do. The engineers are supposed to go on, not like the brook, forever, but from one administration to another, while members of the Corporation Counsel's office often do not, and the members of the Corporation Counsel's office—I am not speaking, of course, of New York only in this, but other cities as well—do not think that it is necessary for them to give up all of their time to the duties of the city, while the engineer must; and the member of the Law Department is giving his time to the preparation of his private cases very often and so cannot devote it to the city's work. So, when the engineer comes on to the stage or on to the witness stand—about the same thing—he cannot give decent explanations; he cannot satisfy the judge and jury; he has to tell them that he doesn't know; but is that the engineer's fault?

The gentleman spoke of the engineer witness not giving consideration to the questions often. That recalls to my mind an answer that was given by a witness in a case in Nebraska; although in that particular instance the witness was a councilman and not an engineer. If any of you have lived in the West any length of time, in the cities that have developed very rapidly, you will appreciate this fact: that one of the greatest qualifications that a witness can have when he comes on to a case that involves any question of public work is, the time that he has lived in the city. It was there, at any rate, one of the most important things that a man could state, to say that he had lived in the city fifteen, twenty-five or thirty years. There was a question involving the condition of a certain street in the city and the opposing counsel put the question to the witness:

"In what state was Harney Street when you came to Omaha?"

(A.) What State? It was a Territory.

(Q.) Well, I say in what state was the street when you came here?

(A.) I told you it was not a State, it was a Territory.

I want to cite that as one instance when the witness did consider the question before he answered.

WILLIAM FOULKE JOHNES, Member of the Society.—Speaking of the contracts on which the engineers of New York City work generally, we have very little to do with the preparation of the contract itself. That, I believe, is approved by the Corporation Counsel, and if there are clauses in there which are unfair or unjust, or which are not in as good form as they should be, because they question decisions of the court or acts made in Albany or in the City Hall, I don't see that the engineer's fault applies to that.

DENNIS FARRELL, Member of the Society.—I would like to ask how the corporation counsel decides on a contract and specifications wherein an act of the Legislature has been passed, making part of it a law. For instance, in such a case as to whether stone should be cut out of the State or not, or whether a man employed as a mechanic or a mason shall get the prevailing rate of wages, or whether he shall get so much per day or per hour. After the contract is drawn up and approved by the chief engineer, it must be sent to the corporation counsel's office for approval. That being the case, if the Act of the Legislature or the Act of the Board of Aldermen or the city officials creating an ordinance approving the Act of the Legislature is unconstitutional, how is it that the Corporation Counsel who has charge of that matter does not at that time find it out? And why is it that the contract will be let notwithstanding and all these clauses allowed to remain in the contract and specifications? Under that condition, aren't those

parts in the contract and specifications just as binding on the contractor who takes and agrees to the contract as those which say there shall be so much stone and so much sand and so much cement, in a batch of concrete? Why doesn't it hold good, too, when it specifies that a stone shall be cut in such a way, such a depth and laid in mortar of such materials, and such jointing, if you please, and so on through the whole specifications? How is it that if those things are unconstitutional in the specifications they are overlooked by the Corporation Counsel at the time they are in his hands and the others are binding to the letter? There seems to be a little inconsistency here.

THE AUTHOR.—I don't know what your practice is, whether it is to answer at this time or not, but I would like to answer the gentleman who has just spoken as to the prevailing-rate-of-wages law. His belief that they were equally binding upon the contractor if agreed to, was one of the arguments of the Corporation Counsel in the trial of those cases. The Court said that provisions of the Labor Law were, without doubt, inserted in city contracts pursuant to the directions of the Legislature in that act, and that they had not binding effect upon the contractors because they were put in there in obedience to the Act and as the contractor had consented to them only as matters of law; they should not be binding upon him. What is more, the Labor Law making it obligatory upon the city to put the Labor Law provisions in there, it was merely a part of the unconstitutional act and the courts would not hold the contractor bound to such Acts. Being merely a naked promise, it has no binding effect. If there were another consideration and they were not inserted purely in obedience to the law, then they would have the same binding effect as any other agreement.

As to the faults of the Corporation Counsel: I can only say the Corporation Counsel's office has many faults. I would not wish to compare its faults with those of the engineer because I would compromise myself, having been a part of both, but if you knew the workings of the Corporation Counsel's office you would wonder that you obtain contracts as promptly as you do. I do not make any reflections on the Corporation Counsel because I think that office is the hardest worked department in the City of New York, notwithstanding observations from members as to outside practice by some assistants in that office. I tell you, gentlemen, that I would not accept the best situation the City might offer and sacrifice my private practice. I had a distinct understanding that I should "keep my shingle up" and that I should give eight hours to the City's work and the rest of the time I should use for my own business, and I did that. I don't know that I admire other lawyers who gave more than eight hours a day, which the Labor Law says is a day's work.

MR. SAMUEL C. THOMPSON, President of the Society.—I suppose since the Labor Law has been declared unconstitutional, that lawyers are not at present held to work eight hours a day for the City. I don't know whether it applies that way or not.

WILLIAM W. BRUSH, Member of the Society.—I don't know but what some of the members of the Society are a little afraid that specifications come too near home and do not wish to discuss something that comes directly in our work, but in Mr. Wait's paper my attention was drawn especially to the question of putting the responsibility on the contractor, which is the keynote of Mr. Wait's remarks. In specifications the engineer usually states that the work shall be done in a certain way and that the means are furnished by the contractor. In carrying out that clause in the specification, the engineer will find that the contractor has the stronger end of the argument and unless the engineer has specifically stated that such and such a thing shall be done, or shall be done in a certain way, he will be unable to compel the contractor to do it. Thus we have practically two kinds of specifications in one. We know exactly what we want done and how we want it to be done and then can describe the work in detail; while in the other form we have to leave it entirely open to the contractor as to how he is to do the work and simply specify what results are wanted and the quality of material which goes to make a good design for the structure or machinery that it is desired to have the contractor furnish.

There is, I think, a tendency on the part of the city engineer to eliminate the question of how the contractor is going to come out financially if all the clauses of a contract are strictly enforced, and also a tendency to eliminate the clauses which will protect the contractor and put in every clause that will only protect the city. In a city contract there are about as many safeguards put around for the city's interests as possible, and I think the specifications should attempt also to protect adequately the interests of the contractor and in so doing they would protect the interests of the city, because the city would get its work done cheaper and also by a more reliable firm of contractors. In this respect, the criticism made by Mr. Wait is certainly just in regard to the New York City specifications. The Corporation Counsel's office discourages the engineer when he tries to put in any clauses which will protect the contractor and encourages the engineer to go to the other extreme and put in every clause to protect the city and leave the contractor to take all the responsibility, for which the contractor is certainly going to charge the city or else take his chances, if he finds he is losing on the contract, of putting in inferior material and work.

MR. THOMPSON.—I think in the case of the city specifications,

they are built, as has often been remarked to me, like a jug handle, all on one side, but I have seen them drawn differently. I have in mind one particular specification that was drawn on a piece of work in this city. After giving in detail how the work should be done, what it should be composed of, how it should be put together, giving quite elaborate drawings and details of almost everything, the engineer who drew the specifications finished up by saying in substance: If I have neglected to put any things in these specifications that ought to be there, the contractor must consider that they are there.

THE AUTHOR.—I would like to give encouragement to some of these gentlemen and to contrast our engineering societies with the architectural leagues. The architectural societies meet and study beautiful things, decorations for doors and church windows and other ornamental features. Engineering societies, not only civil but the mechanical, the Society of Marine Engineers and Navy Architects, get together and the gentleman presents a paper and then he lays himself open to discussion, and if he don't study pretty carefully what he says in his paper, he is going to be contradicted and get into a controversy.

In architects' specifications in New York, as they are drafted and prepared, it may be seen that Messrs. So-and-So would specify "Atlas" cement, another would specify "Empire" and another would specify something else. You cannot get architects of the City of New York to agree upon the same methods of construction, the same method of applying Keene cement, or the same method or way of doing many things. The architects do not get together and discuss these matters, the superiority of materials, methods or processes.

LAZARUS WHITE, Member of the Society.—I would like to ask Mr. Wait, can the engineering expenses which are caused by the contractor taking more time than specified be considered as liquidated damages? Would that hold in law?

THE AUTHOR.—Generally speaking, yes. It is an expense to the owner or city; it is a damage to him and what is called a proximate damage. All proximate damages must be assessed, but first you must prove damages.

MR. WHITE.—Suppose a straight out-and-out $100 a day is specified for extra expenses incurred by the prolongation of the contract.

THE AUTHOR.—I don't think the gentleman knows what he is getting into when he discusses liquidated damages. If you specify $100 a day for liquidated damages you are limited to that and the Court will not allow you to recover more. Damages that you suffer, be they $25, $100 or $1 000 a day, if not specified as liquidated damages, you can recover whatever you suffer. If you specify

liquidated damages and name only the engineers' time, the inspector's time, or wages, you will be limited to that.

RIENZI H. BETHEL, Member of the Society.—Mr. Wait said that the engineer was at fault partially on account of his insufficient tabulation of notes and that sort of thing, and then came out with the statement that the engineer on the stand is liable not to understand the English language. I don't think it is altogether the engineer's fault. Frequently in cases of that sort the author has an advantage, having seen both sides, and doubtless witnesses that come up on the stand under Mr. Wait would not suffer as severely as engineers who come up under other lawyers, because Mr. Wait would appreciate that he had a tender subject to handle in an engineer witness and no doubt would afford him more or less preparation. The ordinary engineering witness for the ordinary lawyer is simply told that he must be in court on a certain day to testify in a certain case. Most lawyers, after deciding to call him, pay very little attention to his testimony or what they hope to gain by it and he is thrown into the contest with a lawyer who, as Mr. Wait says, has a very much better education than the engineer, and the natural consequence is that lack of preparation on the part of the engineering witness generally results in a pretty poor witness. As I started to say, I do not think that is altogether the engineer's fault. I think part of that is possibly chargeable to the non-appreciation on the part of the lawyer of what he expects from his witness.

MR. THOMPSON.—In the matter the last gentleman has brought up, I have had some experience in the courts of the city in the last few years and I have found, with certain lawyers, that the witness for the contractor seems to increase the accuracy of his information in exact ratio to the time that has elapsed since the occurrences. If the time was ten years ago, the information is absolutely accurate. If it is only a year or two ago the information of the engineers is reasonably accurate and sure; the information of the contractor is frequently not as sure, but the longer it goes the more accurate the information from the contractor and his men. But, unfortunately for the engineers, they do forget some things and I have found that after six, seven or eight years, the engineers do really forget some of the minor details about the case, and when they come on the witness stand they are not nearly so certain what occurred as the contractor's men. I discovered that in a good many cases here in the city. I don't know what the particular condition is by which the lawyer refreshes the memory on the part of his witnesses. This is my observation from many cases, in which I have taken part.

THE AUTHOR.—I think I can explain that, or at least relieve any suspicion that it is the lawyer's fault. The fact is that the city

engineer usually doesn't know that there is a suit until three or five years have elapsed. If you are familiar with litigation you know a case is put on the calendar which does not come to trial until eight months to three years after. The lawyer and the contractor's employees soon after the work is completed are directed and instructed to perfect their note books and those note books are treasured in the lawyer's safe and a record is made and the case is made up when it is started and those contractor's superintendents and foremen and time-keepers are kept track of and the result is that every time-book and every foreman's and superintendent's book is kept. A week or two, and sometimes a month, before that case is put on trial, those books are put in the hands of the foremen and they are told to school themselves on the subject. The corporation counsel's office may let you remain in ignorance that there is a suit in regard to it until about four or five days before it is called, and the result is that you have forgotten a thousand-and-one other things about it. I think that explains our President's observations.

GEORGE HALLETT CLARK, Member of the Society.—Mr. Wait, in making criticisms of the failure to complete work on time states, "as aggravating instances occurred in our Rapid Transit construction, which contributed so much to the Elm Street condition," etc., I would say that the author of the paper was in error in stating that the clause limiting openings to thirty days applied to Elm Street, this street being specially excepted, the only condition, except as to bridges at cross streets and access to buildings being, that "not more than two adjacent blocks shall be closed against vehicular traffic at one time." See page 72, contract for construction and operation. When the specifications for the Rapid Transit Contract No. 1 were prepared, the attempt was made to so draw up the conditions which would govern the work as to keep down the cost of construction as much as possible. Plans previously prepared had to be amended and curtailed in order to reduce the estimated cost of the work, due to decisions of the courts. The portion of the system extending south of Ann Street on Broadway was eliminated, the original line of Broadway from Ann Street to Forty-second Street abandoned, and the line as constructed, up Elm Street, Fourth Avenue, etc., was adopted, in order to reduce the expense of construction. The city had taken title to Elm Street, the buildings on the line of the street had been removed, and the street had become a highway, although it had not been regulated and paved, and the contract for regulating, grading and paving was not let until nearly seven years after the rapid transit plans were prepared and adopted.

The letting of the rapid transit contract and, consequently, the completion of the construction were delayed by two causes not traceable to the engineers:

1. In 1897, following consolidation, work on many city contracts was suspended or the letting of new work postponed due to the question of the city's debt limit having been exceeded, the debt limit being then based upon an assessed valuation of 60% of the actual valuation, instead of the full valuation as at present. Was this the engineer's fault?

2. The letting of the rapid transit contract was also delayed in the neighborhood of a year, during which time the contract was in the hands of the corporation counsel for his approval as to form. At the end of this time, contract was returned approved with no suggestions except of an engineering nature, which were not followed. Was the condition of Elm Street from the time proceedings for street openings were begun until July, 1900, the engineer's fault?

Was the necessity for so drawing the contract and specifications by making conditions favorable to economical construction so as to enable the city to obtain a responsible bidder at a price limited by the city and the courts the engineer's fault?

The author's remarks regarding Fourth Avenue and Fourteenth Street, Ann Street and other points, while in part justified by the specifications, show that he is not familiar with many conditions which necessitated the inconvenience to which the public was subjected and the long periods during which the streets were torn up.

Intelligent and fair criticism of the original rapid transit contract and of the methods of construction and comparison with the methods being pursued at present on lower Broadway is impossible, unless many factors, to which no reference has been made, are taken into consideration and due allowance made accordingly. A discussion of the various conditions under which the two pieces of work have been conducted and which have determined the methods followed, would carry the speaker far beyond the bounds fixed by the engineer's duties and in many cases into the territory ruled over by the lawyer, and the speaker believes would largely eliminate the question, "Was it the engineer's fault?" as far as this piece of construction work is concerned.

THE AUTHOR.—I would like to state that I thought I was pretty familiar with the rapid transit contract, having passed upon it and having written many opinions about it. I don't recall any particular observations in regard to Elm Street. That does not, however, excuse in any sense the opening at Fourteenth Street and Fourth Avenue and from Fourteenth Street down to Eleventh Street, where it was open more than two years, at least between Thirteenth and Fourteenth Streets. It does not excuse at all the nuisance we had right at the City Hall and the Staats Zeitung Building. It does not excuse openings at Franklin Square in front

of the Tribune Building, where probably a good many of you remember there was a little hole, perhaps 5 ft. long and 3 ft. wide just south of the Franklin monument, with a fence around it and another fence that jammed the great traffic on Park Row into a passage 5 ft. wide. That hole, south of Franklin Square, was kept open without any work being done there, or for any apparent purpose whatever for three months or more, and when I, myself, notified the engineering department, even to the higher officers, that that hole and contraction was an intolerable nuisance, it was two weeks before it was mitigated. I call attention to the condition of the pavement at the corner of Ann Street and Broadway. You ought to see a coal wagon try to get in position to discharge coal in the St. Paul Building to-day. The pavement is kept open without any apparent reason whatever. I do not think anybody in the engineering profession would come here and undertake to excuse the work of the subway as conducted in lower New York.

I want to apologize, gentlemen, for the length of my paper. That paper might be made eight times as long and not cover half the points that might have been raised.

I would suggest a good subject for a paper and I would invite somebody in the Society to undertake it, not take two months at it but a year or two. It is in the biographical line of work. You are familiar, and if you are not you should be, with Smiles' Lives of Eminent English Engineers. Our Societies ought to collect biographical data and it ought to be made into pamphlets. Something ought to be done to perpetuate the memories of our great engineers while they live and while their work is going on. Public works and articles on engineers and their work can be brought up in the meetings of this kind. If once started and one wrote two or three paragraphs on something historical, about the faults of our great engineers and how great success crowned their ultimate efforts, it would be a profit to us all. If there be one thing we ought all to do in every profession, we should perpetuate the names of the illustrious members of the profession.

I have been asked by a member to-night if I would make some statement from my observation as to why engineers, as a class, are not regarded as professional men and why are they not rewarded in the substantial manner that members of other professions are. A man of gray hairs and a man much older than myself should undertake the discussion of such a question as that. Though I have been in several lines of work, I have not seen the engineer from the outside except from the lawyer's point of view. I might illustrate, perhaps, by a lady stenographer and typewriter that was once in an office with which I was connected. She was not particularly pretty, nor prepossessing, nor brilliant, but she just

carried herself in a way that said "worship me" and the whole office did so. She held herself up to be idolized and she was obeyed. That is one type and style of a girl. Now the engineers—and I say this without hesitation, because I have been associated with a great many men in different walks of life, have been an engineer, have had twelve years of good, hard experience as an engineer—are too conscientious and too humble. Any man who can pursue subjects of mathematics and science combined and conquer them need have no fears nor humility. Any man that can take up the engineering courses of our technical schools and complete them, has got brains and accomplishments when he gets through. When I was in college I was encouraged by my father to give more attention to rhetoric, etc. That I did not do and I have always regretted it. What I have been able to acquire has been simply by practice outside.

I wish some of you gentlemen would go to the Railroad Club and attend its meetings. You will see men get up there and talk persistently and make a good impression and a good address. You will find those men, who have been solely in the shop, without even a high school education, writing papers that a professional man must learn to write and deliver. If you are going to acquire that and are going to present yourself before an assembly, you must make a beginning. I think that is one of the great handicaps of this profession and I would encourage every young man here to get up and make his speech and after you have done it once you won't care; you will make a number of them.

WALTER G. ELIOT, Member of the Society.—Mr. Wait's idea has interested me as much as anything that has come up to-night. He has touched upon the principle which goes to make or mar the permanent success of this organization, *i. e.*, the power of its individual members to express forcefully and tactfully its purposes. A foolish and excessive modesty has denied to the engineer and the technical graduate that recognition which is accorded the lawyer. The engineer is belittled by the community even from the time he entered college. As the author has said, it is largely because you rarely hear one of them take to his feet and properly express his views and sentiments at length. What stirred my interest in his remark was the fact that I also have had a little more experience in newspaper or biographical work than, perhaps, many of my friends here. Some years ago a clever young man, whose father had been a great journalist and famous Member of Congress, said to me, "I would like to start a trade journal. It would better be something connected with university work." I said, "I know nothing about that sort of thing." Well, he said, "I was trained in Yale for journalism and I have been in it practically and successfully ever since. My father taught me the advantage of newspaper

work." Now the first thing he did was to fall in love with his typewriter. He married her. Having relieved his mind of that incubus, he applied himself to the biographical department and found that it was interesting to more readers of his newspapers than, perhaps, any one of ten different subjects treated therein.

Becoming interested in his idea of a magazine, I said perhaps we had better ascertain how much interest there was in the biographical part of such work. Putting it in practice and referring it to Messrs. Hewitt, Carter, Choate, Evarts and several other gentlemen for their opinions, it proved to be the most interesting subject we could publish in the magazine. Thus we started what is now a well recognized branch of every magazine. If you, Mr. President, should inquire in the *Tribune* or *Herald* editorial rooms, you will find your obituary already well written. The finishing touches are usually added within the half hour preceding its engineers.

I think Mr. Wait's point is well taken. Starting in a humble way, we can, in our private records here (which should be catalogued and kept from the moment a man joins) keep a complete record of every member as well as of all American engineers. I think our Secretary has started the ball rolling in the brief little note that he puts in after each man's name in our membership list. It is a perfectly feasible scheme which we will soon find we can enlarge to embrace the more valuable records of our greatest engineers.

We are now an organization in the metropolis of this western hemisphere and the work now being done in New York is only the commencement of the enormous works that combined capital will permit us to undertake. Our organization should, therefore, commence its biographical work at once. Foreign societies, especially the English, beginning with *Transactions* eventually had regular publications in which all the biographical and other matters were indexed so as to form a bibliography of the individual subjects treated.

Anent the subject mentioned by Mr. Wait, the trouble with our engineers before the Society was formed was that few of them knew each other. Departments and boroughs were jealous of each other. Coming together here and becoming acquainted with each other has enabled us to relieve our minds of that jealousy which has been almost a distinctive trait of engineers in this country. Besides this, if we urge that men who are trained in the engineering schools shall be encouraged by the faculty in public speaking or private speaking in their own debating societies, it will help the whole profession. Debating is almost unknown in our scientific schools. It should be emphasized in the scientific curriculum of every great

university here. When we are able to take the floor in a meeting and hold our own with distinguished members of the bar, some of whom have spent but three years in a school of law, then, and then only, will we command the respect and recognition, financial and civic, which civil engineering deserves; and the engineering profession will be recompensed financially in this city better than it is. I think these two points of Mr. Wait's are the key-notes of our success. We should keep a record of what is *said* and what is *done* by our engineers.

SIDNEY W. HOAG, JR., Member of the Society.—In following the remarks of Mr. Wait and the gentleman who succeeded him, an idea has occurred to me which suggests a serious lack in the engineering profession. Ever since this profession became an established fact, it has been marked by an absence of any well-defined code of professional ethics—a matter which I noticed and deplored twenty-five years ago. It seems to me that the profession of engineering is not usually regarded in the same sense as that of the lawyer or physician, and the same recognition is, therefore, seldom accorded to it; and it occurs to me that the fundamental cause of this is the distinct absence of a code of professional ethics. A partial remedy could be effected by making professional ethics a part of the curriculum in technical schools and colleges, and by constant drumming into the heads of scholars a proper sense and realization of ethical obligation to professional brethren; the time might be hastened when an engineer might be regarded as a professional man on a plane at least with lawyers and physicians, and not as a merely salaried auxiliary towards the execution or carrying out of some big enterprise.

MAX L. BLUM, Member of the Society.—That portion of Mr. Wait's paper relating to the status of the engineer interested me very much; yet, when he speaks of the engineer's modesty, with greater truth a less euphemistic term might be employed. We can seek philosphical explanations for this fault, though no excuses. The civil engineer is the product of to-day; professionally he has not yet found himself. There are many here to-night, whose hair has not as yet the gray or silver of years, who will recall the forerunner of the present-day engineer; a ruddy, robust, ready-fisted, open-air fellow, taking an equal pride in his lurid use of unprintable English, and in his Bacchanalian superiority; who would break into the wilderness to build the pioneer railroad; who, being able to disregard cost of material or future maintenance, could throw a bridge across a stream in quicker time than the engineer of to-day could compute the stresses in one panel; who viewed higher mathematics as an educational frill, but by hard knocks of expensive experience knew costs, work and workmanship. This type

of engineer, many of whom occupy the higher positions to-day, has but little professional sympathy for his subordinates. He will strive to show the lowest percentage of engineering expense, spurring those under him onward with the promise of valuable experience (I wish that the law of the land would make it an indictable offence to even speak of "working for experience"). In other professions the measure of prosperity is the average of the many; in ours, the salary of the one who sits atop in lonesome grandeur.

Our technical societies, naturally reflective of the older engineer, bear no less a burden of blame. The grand dukes thereof will frown upon the young man who dares to mention facts and deductions not gained by an experience of decades. The Society will have interminable theses upon some abstruse detail, but never, by any possible mischance, a discussion of professional ethics. They will have the cold, clear-cut impersonality of the crystal. The venerables therein have, by their complete auto-hypnosis of self-aggrandizement, awed the younger members into subjection.

Mr. Wait has compared the young engineer to the lawyer. It is but a surface analogy, that will not bear close analysis. A more logical comparison would be with the lawyer's clerk in some large, legal corporation; for he has about the self-same measure of independence. The young graduate lawyer or physician will starve himself respectably into a competency; the engineer leans upon a salary. Your top-notch lawyer will, in his post-banquet eloquence, prate voluminously of the majesty of the law, the high and noble profession of jurisprudence, but will keep an Argus eye upon fat fees for himself and his professional brethren.

The results of this selfish attitude are many: Work, which of right is within the province of the structural engineer, is given to the architect with the former as a mere under-strapper; river and harbor improvements to the army engineer instead of to the civil engineer; executive order will fix as the compensation to the chief engineer of the monumental work of the ages an amount which, if multiplied by ten, might be self-sacrificingly accepted by the legal adviser in a boundary dispute between two opera-bouffe republics. The engineer in responsible charge of a thousand men on municipal construction will receive as salary an amount which, if offered in less high-sounding wages to a bricklayer, mason or steel-worker, would cause the walking delegate to wax into red-faced denunciation.

Nor are the consequences to the employing public, whether national, State or municipal, less deplorable. Only superficial needs are touched upon. No steps are taken to furnish adequate water supply until the municipality is in imminent danger of a water famine. No additional dockage facilities planned until the com-

merce threatens to be diverted to other ports; transportation facilities so deficient that even the pre-historic horse-car is thankfully accepted; pictures of our boroughs doing duty as maps, more innocent of angles and distances than the Mojave Desert. Our public service corporations digging Pompeian trenches in the public thoroughfares to discover the whereabouts of subsurface mains and ducts; departmental reports published which are mere compilations of petty cash expenditures and locations of minor repairs; men making themselves indispensable because they carry information under their hats which should be kept systematically for future reference.

We might continue thus until we would sprain our tongues, but I merely state that which you all know: The lack of system and co-ordination is truly wonderful.

Our Society, by straightforward, manly, diplomatic action, can remedy all these faults; representing as we do so large a percentage of the engineers of the country, any course of action which tends to elevate the status of engineers will have a wide-felt influence if we but remember, one and all, that engineering is our life work, that our training, ideas and ideals are similar; if we bring about a better *esprit de corps,* eradicate all petty jealousies, then will the public appreciate our services with a better understanding and we will above all be able to respect ourselves.

As matters stand now, work which is necessary for the future upbuild of the communty is never planned until a group of civic idealists re-enforced by financial practicalists force a public sentiment. This should not be so. Let us unitedly act as the scientific prophets of the future; let us be just to the city, just to our profession, just to ourselves and then we will more fully have realized the purposes for which our Society was founded.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK

Paper No. 18.

PRESENTED SEPTEMBER 27TH, 1905.

REPORT OF THE SPECIAL COMMITTEE ON DATUM PLANES.

COMMITTEE: LAZARUS WHITE, Chairman; EDMUND PAYTON RAMSEY, GEORGE J. BISCHOF, EDWARD H. HOLDEN, JOHN T. FETHERSTON.

WITH DISCUSSION BY
SAMUEL C. THOMPSON, BERNARD M. WAGNER, RICHARD W. JONES, DENNIS FARRELL, GEORGE W. TUTTLE, MAX L. BLUM, EDWARD H. HOLDEN AND LAZARUS WHITE.

New York, Empire City by name, is an empire in government; the various boroughs are kingdoms and the departments principalities, and the Board of Estimate is the center and fount of authority. Each kingdom and principality, before consolidation, adopted its own rules and standards, among them being the various datum planes or origin of levels for the work of the different departments; but as these departments overlap and have frequently to work in co-operation with one another, the engineer who has to use the elevations of streets and structures so determined by another department is put to much trouble to translate these elevations to those of the datum in use by his own department.

Because of this, a general wish has been felt for some authentic single table which at a glance would show the relation sought for. But previous to the formation of this Society, the engineers of the city were largely strangers to each other, and there was no way by which such a desire could be voiced. But, fortunately, the Society of Municipal Engineers was organized, and through the fellowship

thus created this need was discussed and found expression in a resolution—

"To form a Committee on Datum Planes to investigate the origin of and the relation existing between the various datums in use by the different bureaus and departments of this city."

How well the committee has been able to furnish the desired information can be readily judged by the contents of its report; but it must be said that what it has accomplished has only been possible through the co-operation of the Members of this Society.

First, as to the origin of the datums of New York City. Some of them originated like Topsy; they have no father or mother; they just grew. Others have been determined by long observations and scientific analysis, others again have had semi-scientific origins, and others again must have originated in the brains of humorists.

The oldest datum, and which should be the most important, is that called City Datum or Public Works Datum. It originated at Bellevue Hospital at the East River some time in the dim and distant past previous to 1840. It was probably obtained from tidal observations by a city surveyor (whether he was temporarily detailed at the hospital I don't know). It is called M. H. W. and is, strange to say, within a tenth or two of actual M. H. W. at Bellevue.

From Bellevue, a line of levels was run to City Hall about 1840 and a basic bench mark, cut deep into the stone just below the water table of that classic building, below the Mayor's window, where the chief magistrate could keep his eye on it. It is a great T about 4 in. long cut deep into the sandstone. Its top bar is only about .04 in. wide, the middle of the bar being used, and by a conclave of City Surveyors called about 1840, it was determined to call it Elev. 42.21, and such it has been ever since. This classic bench mark has been saved to us only by its size. However, it would have been lost through the recent "renovation" of the City Hall, as it was to be removed as a blemish, were it not for the protest of one of the engineers of the city whose attention had been called to it indirectly through this committee. So we are entitled to a vote of thanks from the city surveyors whose scriptural bench we saved.

The Public Works Datum is that used by the Sewer, Water and Highway departments of Manhattan, but through the confusion caused by the distribution of the city works to city surveyors, it is not true to itself and varies in different parts of the borough. The Public Works Datum was taken by the Rapid Transit R. R. Commission in its original work and used ever since, but unfortunately, through a discrepancy in the benches of this system, it does not give the City Hall Bench (Elev. 42.21) within 0.05 in.

The Public Works Datum was also adopted by all the departments of The Bronx and seems to have been the one taken by the Long Island City Commissioners in 1875 in establishing grades in Long Island City, as its elevations agree quite closely with those run into Long Island City from the City Hall Bench. The datum as used by the Highway Department of Brooklyn coincides fairly well with that of the Public Works Datum.

The Pennsylvania Railroad in its improvements in Manhattan and Queens uses the Public Works Datum as does also the New York Central in Manhattan and The Bronx.

To recapitulate, the most widely used datum, that of the Public Works, M. H. W., East Twenty-sixth Street, is used by the Highways, Sewer and Water Department of Manhattan, by all the Departments of The Bronx, by all the departments of Queens, by the Rapid Transit Railroad Commission in all its work, and coincides quite well with that of the Highway Department of Brooklyn, and is used also by the Pennsylvania Railroad and New York Central Railroad. The table may show separations of these datums, but we believe that they are caused by discrepencies which have crept in during and after their adoption.

The datum of next importance to that of the Public Works Datum of Manhattan and The Bronx is the Navy Yard Datum of Brooklyn. The original bench mark of this system is a square cut on the southwest of the coping of Dry Dock No. 1, Brooklyn Navy Yard. This was "conventionally" adopted as 5 ft. above M. H. W. by Mr. James B. Kirkwood, Chief Engineer of Brooklyn Water Works 1856-62. Although this bench mark is over forty years old, it is still perfectly plain and secure, and as the Brooklyn departments have been accustomed to run to it from time to time, they have a perfectly definite datum and an admirable bench mark

to start with. This bench, however, is only about 4.4 ft. above actual M. H. W. which may be due to subsidence of the land or to inaccuracies in the original determination of M. H. W. The latter is more likely to be the case, judging from Mr. Kirkwood's use of the word "Conventional."

The Navy Datum is in use by the Sewer Department and Water Department of Brooklyn, and has also been used by the Bridge Department for their new bridge across the East River and has been carried by them along the water front of New York. The Long Island Railroad also uses this datum on its Atlantic Avenue improvement works.

The history of the various systems of levels in Richmond Borough will well illustrate how they came into use. First, various assumed datums were used when established bench marks were not available. The datum of the United States Coast Survey has been used at times, as also that of the Dock Department which has established a very complete series of benches for Richmond.

In 1890, the County Road Department, under U. S. Bacot, adopted an approximate high-water datum referred to a spike driven in a sewer outlet at Water Street, Stapleton.

In 1899, the Sewer Department of Richmond started another series of benches referred to Battery Datum, but as the old datum had been used by the Board of Public Improvement, these benches were changed to agree with the County Roads Datum, now known as Richmond High Water Datum, and used by all departments in Richmond except the Dock Department. The Richmond Datum is well established, its relation with the Coast Survey and Dock Department being well known. It is really about a foot above actual M. H. W. Some day, when the origin of the datum is forgotten, somebody will come forth with the startling statement that Staten Island has risen a foot since 1890.

Croton Datum used by the Aqueduct Commission is said to be mean tide at Sing Sing as recorded when the old Croton Aqueduct was built about 1840. This datum was used for the old and new aqueducts, and the reservoirs for those aqueducts in New York City and elsewhere.

The only datum in use by any department which covers all the five boroughs is that of the Dock Department. Since consolidation,

this department has run lines of levels along the water front wherever the City of New York has jurisdiction. This datum M. L. W. at the Battery was established by readings of an automatic tide gauge at Pier A, and is based on continuous records from 1886 to 1898. When compared with the average M. L. W. of 814 weeks, it is correct within a few one-hundredths. This datum was adopted in 1898.

Previous to 1898 a datum based on a short reading of a tide gauge in 1886 was used, this older datum being 0.24 ft. below the new datum.

The Dock Department has the most scientifically determined datum of any of the departments, and it is only fair to say, it has the best and most extended series of benches of any department. These benches have been compared and tied in with those of the United States Coast and Geodetic Survey. This department has secured a most valuable series of automatic tide records from various places along the rivers and bays about New York.

After becoming acquainted with the divers and divergent origins of the different datums in use by New York City, the question naturally arises, Which would have been the best datum to have adopted in the beginning?

As New York is a seaport surrounded by tidal streams and bays, it was natural to derive its datum from the level of the ocean. But as the ocean has an apparently fluctuating elevation due to the tides and winds, what should be taken as the ocean level? In the past, everything has been taken, from low water to high water, at various points along the water front, based on records varying in accuracy from the moss line on piles to that given by automatic tide gauges; the fallacy being that any datum referred to any haphazard series of observations was sufficiently good.

In mid-ocean, the height of the tide is only a few one-hundredths of a foot (½ in C. H. Darwin), along islands less than 1 ft., and along continents between 1 ft. and 60 ft. This variation is caused by the contraction of the tidal wave in bays and river mouths; for instance, the range between low and high water is from 2 ft. at the east end of Long Island to 7 ft. at Fort Schuyler, low and high tide varying about equally below and above mean sea level.

About New York City, the tide ranges in height from 4.2 ft. at the Battery to 7 ft. at City Island.

So we see that neither low water nor high water at different points along the water front are likely to agree. But mean sea level or mean tide is fairly constant about New York, despite variations in tides, the tide varying equally above and below mean sea level. It also represents the actual elevation of the ocean uninfluenced by tide, that is, what it would be in the open sea. Even at a single gauge, high water or low water is extremely variable, depending upon the wind, position of sun and moon, etc., and is thus hard to determine. Thus, we conclude, that mean sea level is the best and most permanent datum to refer elevations to.

This is well illustrated by a comparison of Dock Department records with those of the United States Coast and Geodetic Survey. The Dock Department adopted M. L. W. in 1886 as determined by a short running of the tide gauge at Pier A, but in 1898, when a long series of observations was available, their datum was 0.24 ft. Had mean tide level been adopted, a discrepancy of only 0.05 ft. would have been shown, for which small difference it would have been unnecessary to change the datum at all. This old mean tide level would have been within 0.02 ft. of the United States Coast and Geodetic Survey's mean sea level at Sandy Hook. Their present mean sea level is within 0.03 feet of mean sea level at Sandy Hook.

This committee adopted for purpose of comparison the datum of the United States Coast and Geodetic Survey because they had a system of bench marks throughout New York City which had been run by precise levels and to which we could tie the bench marks of other departments. This datum is mean sea level at Sandy Hook and was determined by continuous automatic tide gauge observations from 1876 to 1881. Other observations in 1882 to 1884, and 1886 to 1888 confirm it, so that it can be taken as representing the true ocean level at this latitude.

There is no intention on the part of this committee to recommend that this datum be used by any department of this city which has a datum to which a great deal of work has been referred; nor is there, therefore, any intention to recommend the abandonment by any department of its well-established datum.

It was felt that it would be well to go to an outside source for a datum to which we could refer any datum in use in New York City, and we were fortunate in finding the Coast Survey system of bench marks available. This system of bench marks is still intact to a large extent in Richmond, Brooklyn and Queens Boroughs, but seems to be almost gone in Manhattan and the Bronx, so that indirect comparisons had to be made with the bench marks of some of the departments.

A good deal of discussion has arisen about a supposed settlement of the land at New York and some have maintained that our datums would have to be changed from time to time to keep pace with this change. It is maintained that New York City is settling into the ocean at the rate of 1 ft. or more per century, and that, in course of time, our city will have to be raised out of the waves like Galveston.

Let us examine the evidence. First, we have the Navy Yard bench only 4.4 ft. above M. H. W. instead of 5 ft., but this 5 ft. was only "conventional," and might really have been determined by a few observations and the coping assumed at 5 ft. for convenience, a very good thing to do in the absence of accurate observations. So this evidence is open to doubt. Then we have the change in the Dock Department Datum of 0.24 ft., but this would only be .05 ft. for M. T. L. as we have shown, and even this difference is due to a better series of observations. Then, the marshes along the ocean front of Staten Island and Long Island are lower, we are told, and encroaching on the upland. This may well be, as we know that there is a continual compression of this kind of marsh, which lowers its relation to the sea. This is shown on a large scale in Louisiana, where the settlement of marsh land is rapid. However, the Dock Department records seem to show an upward movement of M. L. W., which would indicate a downward movement of the land for a long period. But the height of the tidal wave above and below M. T. L. is profoundly affected by the configuration of the rivers, shores and depth of water, and as the harbor of New York has undergone great changes in the past twenty-five years due to the filling in of the shores and the deepening of channels, we might expect changes in M. L. W. and M. H. W., especially, also, as the channels into the bay are freer and tidal

basins to be filled less. The observations at Sandy Hook do not show an appreciable change in M. S. L. and we have shown that the change recorded at Pier A for M. T. L. was only 0.05 ft. against 0.26 ft. for M. L. T.

Tidal observations are also greatly affected by winds, which, if continued over a long period, may affect the apparent level of the ocean for a corresponding period, so that it takes many years to establish a M. T. L. free from effects of winds, etc.

The conclusion is that the change in the level of the land at New York is far from proved, and, although there is probably some change, it is very small and not of a constant rate or of a constant sign.

Thus, we are forced to the conclusion that it is most unwise to change a datum because of supposed changes in the level of the sea.

Establish a firm series of bench marks referred to a good determination of mean sea level and stick to them for a century or two is the best method of procedure.

Of course, in past geological periods the land has been at various levels; for instance, during the Jurassic period, according to Dana, the Hudson River flowed through a gorge 2 500 ft. deep to its outlet, 100 miles lower down than the Narrows, and the site of New York City was on the edge of a grand canon. But this was eons ago. In more recent geological times, the land on the lower Hudson has risen and fallen moderately in a range of about 100 ft. Thus, the clay beds along the Hudson, at Croton, Haverstraw, etc., were deposited when the land was lower than its present level; then came an elevation, and these beds were exposed, and are now available to build New York City. In those days of subsidence, all Manhattan, save Washington Heights, was submerged, but the land rose again above the river, to remain so until the destiny of New York is complete.

Some explanation is due as to how the Committee secured the information for this report.

Considerable data collected through a series of years was already in possession of some members of the committee, and by personal inquiry among several members of this Society, considerable information was gathered. Some benches in each borough were

selected from the Coast Survey benches intact; in Manhattan, a Dock Department bench and the old City Hall bench were used. Then letters were sent to the various departments, requesting them to establish the elevations of these benches according to their own system and the results of the runs furnished were compared. It is a matter of regret that all the departments did not respond to our request for runs. When responses were lacking, we were able to obtain comparisons with their benches from other sources.

At this point it is but fair to state that the Dock Department rendered us the most valuable assistance, and through members of that department we had access to their careful and scientific data covering the whole city. The Rapid Transit Railroad Commission also rendered us valuable assistance through their system of levels, stretching from Fort Hamilton to Bronx Park. It was with considerable satisfaction and some surprise that the Committee discovered how admirably the long system of levels of the departments, which covered several boroughs, checked. We might have expected disagreements on opposite shores of the East River, for instance, but here no serious differences developed. For example, we compared four systems which crossed the East River—Docks, Rapid Transit, Bridge and Coast Survey—and only developed differences of a few one-hundredths feet.

Our main difficulty has been with the smaller departments, those which have in the past had considerable of their leveling work done by city surveyors. In these cases the benches are not consistent with themselves, and we are only able to give generally agreed differences with other departments, and the differences based on the original starting bench.

The diagram here reproduced in lantern slide, Plate LII, shows what information we could obtain boiled down so that the relation of any department's datum planes with that of the United States Coast and Geodetic Survey can be discovered at a glance, and almost as quickly the relation of any plane with that of any other department.

It will be noticed that the United States Coast and Geodetic Survey plane is that used subsequently to 1898. Previous to 1898, the datum was apparently 0.106 ft. higher for New York City. This is only an apparent change of datum, however, as it is not

due to a change of tidal observations or M. S. L. at Sandy Hook, as the observations subsequent to 1887 confirm the earlier ones, but is due to a revision of a bench at the Raritan River. This had the effect of raising all the benches in New York by 0.106 ft., the amount of the revision of bench mark "F." This is observed in the report for 1900, however, so that one is misled into believing that the datum was changed due to new observations at Sandy Hook, rather than an original error made at bench mark "F."

It will be noticed that several planes are "bunched" as R. T. R. R., Highways, etc. This is because they all were originally derived from the same source, and through various inaccuracies have separated. They illustrate the need of having several well-distributed and well-established benches to fix a datum plane and show the result of a lack of these.

The difference given here between any plane and that of the United States Coast and Geodetic Survey can be taken to give very closely the elevation of that plane above mean sea level at New York City. If to the Dock Department M. L. T. at the Battery we add (2.21) half the average rise of the tide as determined by gauge at pier "A," we come every close to the Coast Survey Datum. This shows that Battery Datum is really M. L. W. and Coast Survey Datum actually M. S. L., both what they purport to be, which cannot be said of the other so-called low tide or high tide levels.

This Committee has been forced to the conclusion that there is a deplorable lack of reliable benches in existence in this city. Those that do exist were established at different times and by different departments, so that each group is usually known to only one department. Adjoining groups are referred to widely different datums. Our attention has been drawn to the work of the United States Coast and Geodetic Survey, which, in co-operation with the City of New York, is establishing a system of primary triangulation for the Greater City.

It has been suggested, and we see no reason why it cannot be done, that the United States Coast Survey could establish by the same arrangement under which they are now working here, a system of bench marks referred to their datum at Sandy Hook. To do this, it would only be necessary to re-run their former levels

in this city and spread them more widely. Metal plates, each with a projection for supporting a rod, could be fastened to public buildings and school houses, and the elevation of top of projection established and stamped with dies on the plate. School houses are admirably adapted for holding benches, being on good foundations of a uniform distribution and well known. It would be a great comfort and save an enormous amount of running and re-running of benches, if a reliable bench, according to a well-established datum, could be found on the nearest school house. Such benches, as outlined above, being run by the exact methods of the Coast Survey, would not be open to doubt, and the relation of its datum to the other city datums being now established, could be used freely by all departments.

It seems to the Committee that this work, in proportion to the expense involved, would be of the greatest benefit to the engineers of this city, and it, therefore, recommends that this work be done by the United States Coast and Geodetic Survey in co-operation with the City of New York. It is a rare opportunity and ought not be allowed to pass, without settling once for all this vexed question of bench marks.

DISCUSSION.

SAMUEL C. THOMPSON, President of the Society.—Gentlemen, I know you have been very much interested in the paper given by Mr. White, and I have no doubt many of you have been in the same mill as I have in the question of establishing the relation, not between different lines of levels between different boroughs, but in establishing a datum that would go in a single borough. In the Borough of The Bronx, the original datum from which the benches were run, was a cut on the Harlem River Bridge, on the north abutment, which was cut into the stone and marked "10 ft. above mean high water." When the new Third Avenue Bridge was built, the old one was demolished. Prior to that time everything had been referred to this height, and until the division of the work in that borough, *i. e.*, between the highways and the sewers, there was no diversity in the benches, excepting individual variations made by parties who ran the different systems of levels. When the bureaus were separated under the Commissioner of Street Improvements, the Sewer Bureau started to establish benches for themselves, and the Highways Bureau did the same. There were some trifling variations to commence with. Each bureau, as was perfectly natural, insisted that it knew how to run levels and the result was that, neither bureau being willing to give up that the other bureau was doing better work, each stuck to its own determination. The result was that in less than 2½ miles from the Harlem River at Third Avenue there was a variation in elevations, in some cases, of .3 to .4 feet. The immediate effect was, that when sewers were built and basin heads were placed by the Sewer Bureau, they were placed according to their elevations; when the Highways came along and put curbs on the streets adjoining these basins, the Highways were just as persistent in their idea that their work was correct, and they ran the curb up to the basin heads and it showed, as I have seen in some instances, a difference of 5 in.

You ask what the reason was. Well, we could not agree with the other bureau as to the benches and that thing continued until the present condition under the Borough President, when a system of accurate benches was run throughout almost the entire borough, and after a time the Highways and Sewers got together and at the present time are using the same datum. The benches were run over a very extensive line and then checked and then intermediate benches run between the different courses and adjusted all the way around, so that at the present time we think we have pretty accurate benches throughout the borough, and we are all working from the same base.

I think, perhaps, other boroughs may have had similar experiences. I would be glad to hear from any one in relation to it.

BERNARD M. WAGNER, Member of the Society.—The Committee has done great work in this matter; they are too modest. I see no reason why the different departments should not adopt the datum which they have suggested. The work entailed therein would not be of a nature to stagger the working force of any department. They say that arrangements could be made with the United States Coast Survey to establish these benches, and if this is done, it will be a very simple matter to change existing records and plans to conform to this new standard. I think that if those among our members who happen to be chief engineers would take the matter in hand, it would help things considerably.

A MEMBER.—I would like to ask Mr. White whether he came across two highway datums in use in Brooklyn.

THE AUTHOR.—The Brooklyn Highway datum is one of those Topsy datums that I spoke of. Nobody seems to know where it came from. The oldest engineers over there cannot say. There is no place where you can pin it down to a definite elevation, but it seems to be the consensus of opinion that it is some 1.08 above the sewer datum. I don't know how they got the .08.

A MEMBER.—We always used 1.0 ft. above the sewer datum for the highway datum.

RICHARD W. JONES, Member of the Society.—The same condition which confronts the various boroughs of the City confronted the Pennsylvania Railroad. It has a very long and spreading system, which is made up of various leased and purchased lines. Each particular system which it absorbed had a separate line of benches based upon an arbitrary primary datum which had no relation to any of the others. Finding itself in this condition some years ago, the Pennsylvania Railroad established from the Coast Survey—it is some years ago and I cannot speak exactly from memory—but it adopted some particular bench which it took from the United States Coast and Geodetic Survey. It went through just such a course as the Committee has gone through and adopted and placed tablets and marks on bridge piers, public buildings and other suitable places in various cities. Bronze brackets were inserted in walls with the elevation recorded on each of them. It has issued a book of bench marks which gives a reliable and carefully run line of benches throughout its territory, including newly acquired lines, and, on the latter, the elevations of the benches are changed to conform to the primary datum plane of the Company. Whenever new changes are made in the elevations of benches on account of previous errors or otherwise, a special notice is issued on a printed slip which is to be inserted in the book, giving the new elevation.

The City's problem is a similar one and should be treated in the same manner. There does not seem to me to be any great difficulty

in changing the recorded elevations of established benches to correspond with the zero plane of the United States Coast and Geodetic Survey, as recommended by this Committee. It could be done by all of the chief engineers of departments and bureaus acting in unison. I think that the Committee was rather too modest in not recommending that such a change be made. It may be its intention to do so after the Coast Survey has run the City benches as is proposed to check the differences found by calculation.

DENNIS FARRELL, Member of the Society.—I would like to ask Mr. White if he knows of two datums in the borough of Manhattan and which of the two are considered the most reliable, the City Hall or the one at Bellevue Hospital?

THE AUTHOR.—They are the same. The bench at City Hall is the one from the Bellevue Hospital. I understand it checks very well with the Bellevue Hospital bench, the original bench, so that there is only one datum, not two. A surveyor downtown would take elevations from the bench down at City Hall and those uptown would take their elevations from Bellevue Hospital.

MR. FARRELL.—I do not think they agree. There is a difference of about 0.23, the City Hall bench being the highest.

THE AUTHOR.—I have never run it personally, but I have the assurance from people in the Highway Bureau that it does agree pretty well, so that is all I can say. They have had 60 years to run those two benches and I think by this time they ought to know.

GEORGE W. TUTTLE, Member of the Society.—It is interesting and profitable to have brought to our attention the various datum planes employed and the relations between them. Were common bench marks used in the different systems there would be great danger of using erroneous elevations, and with the independent sets which probably exist there must be some liability of using wrong benches.

Many of the bench marks have been established, no doubt, by long lines of levels without cross connections, and it is inevitable that when two such systems are connected the difference between them will be found to vary from point to point, and cause difficulty in joining any construction common to the two systems. In fact, where work referred to one system joins work referred to another system, it is necessary for one party to find the benches and elevations used by the other, that their constructions may properly join.

The unsatisfactory and incomplete character of these numerous systems is obvious, and evidently calls for a system of levels of so precise a character that it will command acceptance. Such a system will be a network of polygons preferably not over two miles in perimeter, in order that possible errors of observation can be promptly detected and limited to an inconsiderable amount. Of course,

accurate observation and careful adjustment of such a system will be for nothing if the bench marks are not of a permanent character, and in this particular there is great room for improvement.

The City of Chicago has recently, in order to remedy the evils resulting from conflicting references to City datum, established standard bench monuments about a mile apart, built of a heavy mass of concrete below the surface of ground, in which a copper bolt is inserted, the whole being protected by a suitable iron cover. This seems to be a move in the right direction, and is economical in that it will save much time lost in attempting to check benches which will not check.

Where benches are not of an absolutely permanent character, I think it good policy to place them in pairs near enough together that one can be checked from the other at one set-up.

Our principal difficulty, however, is not in the number of datums, but that our datum planes, as we call them, are not planes or level surfaces, and are so far from being such surfaces. This can only be remedied by networks of levels carefully adjusted as above mentioned. The datum used is relatively unimportant, although a single one is doubtless best for the sake of simplicity, economy and freedom from error.

The writer does not know why high water has been so commonly selected as a datum, although there are a number of reasons for its use; for example, it is often necessary to determine grades of streets and sewers in relation to the level of high water. It was important for the early surveyors to trace this line, since all land covered by high water is deemed to belong to the State unless it has been alienated. Moreover, high water is very easy to determine offhand approximately, since it is about the level of tide marsh, is fairly well defined on piling and other partly submerged structures, and leaves its trace on the beach as the tide recedes, while the other tidal constants are more difficult of estimation. When, however, close instrumental determination is required, mean sea level is somewhat easier to determine accurately, since it is subject to fewer forces causing it to change; besides, it is theoretically a level surface and that about which the tides oscillate. On the other hand, mean high tide and mean low tide rise and fall respectively by approximately equal amounts above and below a level surface as the tidal range increases, and the converse is true as the range diminishes.

A striking example of the stability of mean sea level during local changes was shown in the improvement of the Harlem River. At the easterly end of Dyckman Cut the tidal range was reduced from 6 ft. to 3.8 ft., mean low water was raised 1.1 ft., mean high water depressed a like amount, while half tide level remained unchanged.

In 1860 the French Government fixed the datum of all levels for France on the mean level of the Mediterranean Sea, at Marseilles, and the connection made by the "Nivellement Général de la France" with the neighboring systems which included points on the Mediterranean, Atlantic, North Sea and Baltic Sea, show that these sea levels were substantially the same.

The datum for the level of the ordnance survey adopted by the English Government is the mean level of the sea at Liverpool as ascertained from observations in 1844, 4.67 ft. above Old Dock Sill at Liverpool.

In Germany a point 37. metres below a mark on the observatory at Berlin is used as zero, which is approximately the mean level of the Baltic Sea at Swinemünde.

Nearly all national surveys use mean sea level as the zero. The accurate determination of mean sea level offers considerable difficulty, however, on account of irregular fluctuation due mainly to changes in winds and barometric pressure. There is quite a regular seasonal variation due to these causes at New York, by which the mean sea level is about 0.55 ft. higher in August than in January, and a very irregular oscillation having a period of about eight years, also due to meteorological changes which we have to contend with.

Mean sea level is usually determined from hourly ordinates measured on the record sheet of an automatic tide gauge. This is quite a tedious process, however, and often simply the average of high and low tides are taken. We have then not mean sea level, but half tide level, which departs more or less from the former according to the shape of the tide curve. At Pier A, Battery, mean sea level is about .07 ft. higher than half tide level.

It is necessary to employ a very small opening in the tube in which the float of the tide gauge rises and falls, so that the gauge will not register every passing wave, and the principle employed here is ingenuously utilized in the instruments used with success by the "Nivellement Général de la France" to directly measure the mean sea level at any time. The instrument is called a "medimaremetre," and consists of a tube closed at the bottom by a layer of fine sand, through which the water percolates so slowly that the level inside the tube does not follow the rise and fall of the tide outside, but is sensitive to long period oscillations of sea level only.

The recent tidal observations on the Atlantic Coast of the United States cannot be satisfactorily explained except on the basis of a slow subsidence. This movement has, however, been combined with meteorological changes, and has been observed for so short a time that its magnitude does not exceed the extreme meteorological fluctuations.

The above remarks will show the difficulty of determining mean sea level at any time and the impossibility of finding the same value from tidal observations at another time. It is clear that the mean sea level used as a datum should be fixed by reference to a monument of the most stable and durable kind.

The phenomenon of changing shore line has been the subject of discussion since the time of Strabo, some contending that it is the land and others the sea which oscillates.

H. W. Pearson, Duluth, Minn., in *Geolog. Mag.*, 1901, and *Jour. Soc. West. Eng.*, claims from a search of past records that sea level has a vibration period of about 640 years, 320 years from high to low water; amplitude 15 or 20 ft.; maximum during the years 875 and 1500 A. D., and minimum in 1810.

Dr. Holst, *Geolog. Mag.*, 1901, "The Glacial Period and Oscillation of the Land, Especially in Scandinavia," claims removal of ice pressure started oscillations of the land which are decreasing in amount. "Scandinavia has sunk for the third time, and the rising is now going on."

Archibald Geikie, Anniversary Address, May, 1904: "The changes of level, of which our island (Great Britain) furnishes such signal illustrations, have been primarily due not to any oscillations of the surface of the ocean, but to movements of the terrestrial crust connected with the slow cooling and contraction of the globe."

Prof. Suess, on resigning his professorship in the University of Vienna, stated, on the other hand, that "the older view of the numerous oscillations of the continents has also given way more and more to the teachings of marine transgressions."

Prof. Salisbury, of the Geological Survey of New Jersey, states that since the last glacial period the rise of the surface has been as much as 40 to 60 ft., and may have been much more.

Subsidence in recent geologic time has been reported by Lyall and Dawson in Canada, Cook in New Jersey, Tuomey in South Carolina, and others.

The following diagrams show the fluctuations of mean sea level as well as the meteorological forces to which they are largely due.

Plate LIII shows how the mean sea level fluctuates from year to year. It is apparent that these fluctuations are for the most part meteorological phenomena, but the progressive increase in the values of half tide level at New York cannot be explained on that basis, but can only be satisfactorily accounted for by the gradual subsidence of the adjacent land. This same progressive elevation of mean sea level in relation to the shore can be shown to be taking place all along the eastern coast of the United States.

The remarkable fluctuations of half tide level in 1874 and 1878 appear to be directly due to the unusual barometric pressures of those years, and the high barometric pressure in the year 1904 was

no doubt the cause of the lowering of mean sea level in that year. At some ports the yearly average of the atmospheric pressure has a much closer relation to the yearly mean sea level than appears from the above diagram at New York. Similar diagrams at other ports on the Atlantic Coast of the United States indicate that the meteorological effects are very much the same as at New York.

Plate LIV represents some of the most complete and extensive tidal records in existence. Those at Stockholm show a progressive rising of the land to the amount of nearly 2 ft. since 1774, while the tidal records at Travemünde, some 400 miles south and also on the Baltic Sea, show no appreciable change of a secular character in the relation of the shore to mean sea level.

This diagram can hardly be explained on the theory of "marine transgression," and furnishes weighty evidence of the movement of the land.

Plate LV shows the seasonal fluctuation in half tide level, and the meteorological phenomena to which it is due at New York. It is apparent from this diagram that a short series of observations of mean sea level might give a value considerably in error.

The important effect of the northwest and west winds on the seasonal variation of mean sea level is to be noticed. During northwest or westerly gales mean sea level has been at times depressed as much as three feet.

Plate LVI shows the miles traveled by the wind in the directions noted, as well as the number of hours during the year in which winds in each direction blow. The greater intensity of the northwesterly winds, as well as the considerable portion of the time in which they blow, is to be observed. The northwest and westerly winds have for these reasons, and from their direction being in line with the ebb current, such an important effect on the mean level of the sea.

Figure 1 (Page 224), shows the difference between mean sea level and half tide level. If the tide wave was of the pure harmonic type represented by the equation $y = \cos. x$, mean sea level and half tide level would be identical, but when the shape of the tide wave departs from the harmonic form, the difference may become sensible. Mean sea level can then be determined as accurately as required by averaging the hourly ordinates.

A tide curve not in the harmonic form can be analyzed into a fundamental harmonic wave and other harmonic waves whose periods are $\frac{1}{2}$, $\frac{1}{3}$, etc., of the fundamental; thus in the diagram the actual tide wave is supposed to be made up of the fundamental harmonic M_2 having a period of 12 hours 25 minutes, and the second harmonic M_4, whose period is $\frac{1}{2}$ the former. It will be noticed that the effect of the latter component, located as it is, is to increase the elevation of both high water and low water, as given by the

fundamental M_2, by nearly the semi-range of the component M_4; consequently half tide level is raised the same amount above the mean sea level plane.

Yearly averages of half tide level should not have a probable error greater than .05 ft., although the error may be occasionally three times as great due to abnormal meteorological conditions.

The table below gives values of mean high water and half tide level at various points in New York City; referred to C. & G. S. datum of 1899. These values are subject to the errors of tide gauge, errors due to unusual meteorological conditions, as well as to the errors of the level runs to the various tide gauges. The different values of half tide level furnish a rough means of estimating the magnitude of the resultant errors.

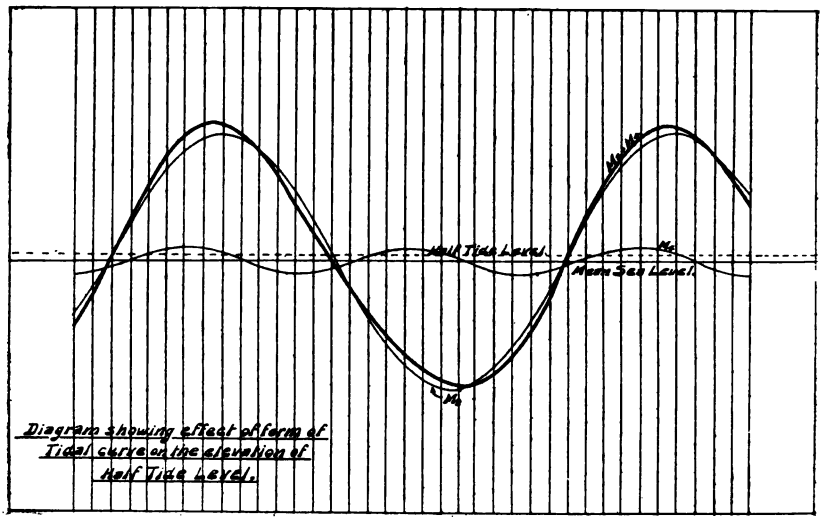

FIG. 1.

M. H. W. AND H. T. L. ABOVE C. & G. S. DATUM, 1899 AND 1903.

	M. H. W.	H. T. L.
Fort Hamilton, The Narrows	+2.40	+.09
Pier A, Battery, Hudson River	+2.16	+.04
West 132d St., Hudson River	+2.12	+.245
East 24th St., East River	+2.07	+.07
Port Morris, East River	+2.98	—.155
City Island, East River	+3.63	+.145
Third Ave. Bridge, Harlem River	+2.52	+.175
Broadway Bridge, Harlem River	+2.00	+.130

MAX L. BLUM, Member of the Society.—I would like to voice the motion embodying Mr. White's suggestions: that this Society urge upon the Board of Estimate and Apportionment that in conjunction with the Coast and Geodetic Survey, a series of precise levels be run covering all the boroughs and that this Society endeavor to bring about the acceptance of the Coast and Geodetic Surveys datum plane by the various departments of the Municipality.

EDWARD H. HOLDEN, Member of the Society.—In regard to changing the datum of any department, I think it would be well to go slowly. There would be no question as to the advisability of having these precise levels run, and yet there might be a question as to changing the benches where the streets have been set to grade established by filed grade maps. Here a change of benches would effect an error of construction. A street graded correctly by the old benches would be incorrect either above or below by just the change in the benches. My idea would be to have the work of precise leveling done and to be used as a reference line, it being optional to change the datum.

MR. WAGNER.—In reply to the remark just made by the gentleman, I do not see how that would apply. If all the levels were run at one and the same time, a street formerly 29.8 might be 29.5 and the changing of the reading of the level would not make any difference. It would simply be to change the record and not to change the grade as established.

MR. HOLDEN.—The same thing stands. The grade maps are filed and the bench marks are not filed, and can you change a filed map?

MR. THOMPSON.—I think the entire object would be accomplished if the accurate benches could be established by the Geodetic Survey and then the datum and the variation put upon the plan. I think that would give the relation between them, which, as I understand the object of the motion, is to give the relation between them so that benches from one portion can be referred from one to another, or from one borough to another, and it seems to me this would be accomplished by getting the accurate levels run by the Government and then, if it was necessary, to call attention to it; let the difference in datum be put upon each plan.

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THE DESIRABILITY OF COMPREHENSIVE MUNICIPAL PLANNING IN ADVANCE OF DEVELOPMENT.

BY CALVIN TOMKINS, ESQ.*

The wonderful growth of New York City and the fact that the City is rapidly assuming the position of the metropolis of the world, creates interest in all plans connected with its development. By the State census of 1905, which has just come out, you will notice that we have a population within the five boroughs of four million one hundred and fifty odd thousand inhabitants. Taking into consideration the four northern counties of New Jersey and the Westchester district, the Connecticut district and Long Island, adjacent to New York, the population of the metropolitan district of New York is certainly not much under five and one-half million people at the present time. There is only one other city having a larger population—the great city of London, with six and one-half million people contained in its metropolitan district of 700 square miles—and it is to be noted that the rate of growth of New York is very much more rapid annually than that of London. Between 1890 and 1900 the City increased 37% in population, and it is estimated by good judges that during the next ten years, as a consequence of rapid transit facilities and other underlying causes, it is not improbable that the City will increase 45%. When we consider the significance of this and what future possibilities are involved, we understand how important the present planning of this great metropolis is.

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The City of New York is a great city on account of its peculiar position. The great city of antiquity was Rome, as a consequence of its position in the Mediterranean basin. The supremacy passed in sequence to Venice and Genoa, and subsequently to Amsterdam and London. Now it is rapidly coming to New York. New York is situated at the mouth of the Hudson River Valley, which is backed by the Mohawk Valley, through which we reach the great waters of the West by railroad now, as formerly we did by the canoe and the canal boat. The only other cities which have any strategic position on the Atlantic seaboard are Montreal on the St. Lawrence and the city of New Orleans on the Gulf of Mexico. The one is interfered with by the cold of winter and the other by the heat of summer. In the case of every other city along the seaboard, the trains coming to it have to climb up over the Alleghany Mountains and down again, and the expense is heavy as compared to the level haul from the West to New York. The situation of the city is such that it already commands the commerce of Europe. New York is situated in the North Atlantic Basin, that vast district bounded by the Ural Mountains on one side and the Rockies on the other—in such a way as to make it the central point of exchange for the great commercial states of modern times. The fact that the transportation of the world is coming to its gates makes New York the city that it is.

It is incumbent on us to arrange our own plan of internal city development so that it shall be commensurate with the destiny which is awaiting us as the result of our situation. The features of New York have actually been too large to have been taken advantage of until the present time. The East River on the one side and the Hudson River on the other have heretofore disadvantageously divided the city. At one time the Harlem did so, but that has been overcome by bridges. The bridges over the East River will similarly do away with the barrier effect of the East River and the tunnels which are now being built under the Hudson River will have the same effect there; so that ultimately we shall see the Long Island section and the New Jersey section connected with the Manhattan section just as conveniently as the Westchester section is at the present time, and we shall then have here a round or square city like Chicago or Paris. The water to the east and west of us will

afford facilities for carrying heavy goods, and passenger transportation will no longer be interfered with by the rivers. We are only beginning to organize so as to take advantage of our natural opportunities.

I have referred to the metropolitan district about New York—the section not alone included within the five boroughs, but comprising the four northern counties of New Jersey, Long Island outside of Queens, the Westchester and Connecticut districts, all as much a part of the social and economic City of New York as the five boroughs.

New Jersey has now under consideration a sewage plan for the whole Passaic Valley and is looking forward to its development so that it will fit in with what the City of New York does. It is looking forward to the development of its middle section in the Hackensack and Passaic Valleys, which can undoubtedly be made the greatest freight terminal in the world. The water facilities here are excellent and the opportunity for conducting factories and warehouses and steamship terminals and railroads exists here as it does nowhere else about the City of New York. Back of the meadows, back of Newark, up toward the Oranges, lies that splendid highland section, much of which has been very little developed as yet; all that country between Paterson and Morristown is almost unknown. This is an integral part of New York City, as is the Long Island district, and should be considered in connection with its development.

The present time is critical because we are called upon now to make important decisions and we have only begun to realize what the consequences of those decisions are likely to be. The public improvements in New York have not been carefully thought out in advance. You know, for instance, what the difficulties have been in connection with planning the East River bridges. I think, without exception, they have been built without regard to their approaches, I was told by Mr. Lefferts Buck that when he suggested to the Bridge Commissioners some years ago the necessity of considering this matter in advance, he was informed that they were empowered by the Legislature to build a bridge and had nothing to do with the approach. And so every bridge, from the inception of the Brooklyn Bridge down to the Blackwell's Island Bridge, has

been planned without reference to its approaches, and that is illustrative of the lack of foresight in general development of the City. I think now, however, a wider view of public matters is being taken and we are not likely to make as many serious mistakes.

As far as we have had any plan of development, it has been very largely that of private enterprise; enterprising real estate operators, acting in concert with enterprising transportation speculators, have developed the City. Most cities are developed that way. This is not a matter of such relative importance to smaller cities, but with a city such as we have here it is of the greatest importance. Transportation is regarded from the point of view of the greatest immediate results in the way of railroad fares. Street and park systems considered largely as to how they can be made to fit in with little separate schemes for real estate development and the desirability for a comprehensive plan are only beginning to be apparent. One of the most notable events in recognition of this fact was the appointment by Mayor McClellan of the City Improvement Commission. Most of you are doubtless familiar with the report of that Commission, a most admirable report, recommending many improvements, some of which may now be open to criticism in view of the wider experience had, but which, in the main, is as effective and as practical as it is broad in its scope. In recommending to the Board of Aldermen the appointment of such a commission, the Mayor said—and I cannot do better than to quote his language in that matter, because it is very precise: "The great error of the past, both from the material and artistic standpoint, has been that public improvements have been undertaken only to meet the emergency of the moment and without regard for ultimate ends. Public buildings have been scattered far and wide or erected in impossible locations. Streets have been opened, bridges built and money spent at haphazard, according to the fancy or whim of changing administrations, with far more regard for the interest of individuals than for the good of the City as a whole."

Private enterprise has conflicted with public works and the good of the individual has not always been the public good, although the results are unexpectedly better than I think we could have anticipated. A plan such as I have suggested cannot be a hard and fixed plan; it must grow and change with changing conditions.

But I think it is important that the desirability for, and the main features of, such a plan should be established in the public mind. My own impression is that such a plan is likely to grow largely as a result of local interest in local affairs in the different boroughs. The different improvements will be brought to the attention of the local boards and then to the attention of the Board of Estimate and Apportionment, and forwarded by a public opinion, first local in character and subsequently general among all the boards as the relation of local improvements to a general scheme becomes apparent. In that way they will finally become so fixed in the public mind that they will perforce be carried through by successive administrations.

The great difficulty has been that one administration succeeds another administration so rapidly, and that private interest is so constantly at work, that it is very hard to maintain a continuous policy. But if we arouse sufficient general public interest in these matters the force of opinion will compel the Board of Estimate and Apportionment and changing city administrations to carry through consecutive borough plans.

As regards the practicability of specific improvements, this body of technical men in the City employ is, by criticism and encouragement, more capable of directing public opinion correctly than any other body in the City, and a correspondingly great responsibility rests upon it.

To be more specific: the general idea of a city plan includes the following subsidiary ideas:

The first matter of importance is planning for city streets and parks, first, in the outlying boroughs where the field is open, particularly in Richmond, in The Bronx east of the Bronx River, in Queens, and rearranging streets and parks in the older parts of the City. The park and the street arrangement should go on at the same time. It is impossible to plan a good street and park system unless they are planned together. Changes and rearrangements in the older parts of the City are enormously expensive. The acquisition of small parks, while very necessary, is an exceedingly expensive operation for the City, and widening or changing well-established street lines in the older parts of the City is also extremely expensive. London is feeling the great lack of City planning in this

respect. There they are obliged to make important street changes at a heavy expense, and here in the City of New York we have got to do the same thing. This has been effectively done in Paris and in Vienna, and done at a time when the changes could be carried out far better and easier than they could now. In Vienna this was accomplished when they tore down the old fortifications, and in Paris they did the work under the strong hand of Napoleon III. We must widen Fifty-ninth Street when the Blackwell's Island Bridge is carried across to Manhattan. We must extend Sixth and Seventh Avenues downtown. We must make some provision, I think ultimately, for diagonal streets between the bridge terminals of the Williamsburg and Manhattan Bridges and the downtown section and the Cooper Union section, and there are numerous other street changes in addition to the acquisition of small parks. We are now paying for our lack of foresight in these respects. However, in the new boroughs, the opportunity exists and should be taken advantage of, and it will be most unfortunate if it shall be longer neglected.

The next matter is that of bridges and tunnels, including docks, ferries and warehouses. As I have indicated, bridges and tunnels will serve to connect the whole city together and make it a round city instead of a long city. Bridges are virtually sections of continuous streets and ought to be so considered.

In connection with the warehouses I would like to leave one thought with you. Many cities have excellent warehouse systems. In New York, in Manhattan at least, we have no adequate system. The sheds on the piers are virtually the warehouses and the immense rentals that they command for the double purpose of landings and storage makes the docks unavailable for other purposes. Domestic and foreign commerce is suffering as a consequence for lack of good landing facilities and this will continue as long as the docks are used for warehouse purposes, when warehouses should be provided elsewhere.

The opportunity for acquiring parks in Richmond, and seashore parks on Long Island, and an immense park on the submerged lands about Jamaica Bay and in Queens, exists at the present time, and that situation is not going to exist long. Fortunately, the Borough of The Bronx supplied itself with a magnificent system of

parks some fifteen years ago, but the same judgment has not characterized the Borough of Brooklyn or the Borough of Queens, or the Borough of Richmond, and in each one of those boroughs there are splendid opportunities for the acquisition of cheap parks at the present time, which should be availed of.

The harbor is under the jurisdiction of the United States Government as regards its commerce and as regards dredging, but the matter of the pollution of the water itself is a matter that has not received the consideration that it should. The sewage from all that section back of the ridge on Long Island is coming into the New York Harbor through cross sewers; the Bronx Valley sewage will be deflected into the Hudson River; the Passaic and Hackensack sewage will be deflected into New York Harbor. The water in the upper harbor now is foul compared to what it was a few years ago, and unless some purification system is provided for the increased drainage which runs into our harbor, the conditions will, before very long, be as bad as they are in the Passaic Valley now. They are unbearable there at present, and the harbor should not be converted into a cesspool.

The matter of the grouping of public buildings and of the development of sections of a city so that there shall be uniformity of character is a matter that should receive attention. Cities are beautiful just about in proportion as their public buildings are effectively grouped about centrally located public squares. That constitutes the great beauty of the City of Paris and Vienna—the two finest cities of the world from an æsthetic standpoint. Many of you remember the wonderful effect that was created at Chicago during the World's Fair by the grouping of buildings. We have neglected this in New York City. I had a map made some time ago showing the public buildings in the City of New York and I was surprised when the map came out to see how dotted it was with the parcels of property belonging to or leased by the City of New York scattered all over the lower part of Manhattan. If those buildings, fire engine houses, school houses, court houses, libraries, department offices, etc., were properly grouped at centrally located points the effect would be very different from what it is now. The important site in connection with this matter now is City Hall Park. If we lose the opportunity of making a civic centre and a

beautiful square out of City Hall Park, we shall have lost the greatest æsthetic opportunity in the city. The new Hall of Records on Chambers Street is the key to the situation there; the north side of Chambers Street should be taken by the City and the Hall of Records extended along it to Broadway. The antiquated United States Post Office Building should be taken out of the southern extremity of City Hall Park, where it is now located. Many people do not know that it is standing in the original park enclosure, but such is the fact, and the land was deeded to the United States Government for a nominal consideration. It should be taken out and the ground returned to the City. With that share in front, with an adequate bridge approach at Park Row, City Hall Park would compare favorably with some of the beautiful European squares which will be shown on the screen later. It is a matter of convenience to have public buildings grouped in places where they can be conveniently reached. Chicago, Cleveland, St. Louis and Buffalo, and particularly the City of Washington, realized this, and all of them planned elaborately for the future and particularly with reference to this matter of the placement of public buildings effectively and so as to create grand effects. Architects have very properly stated the matter in this way: That two public buildings properly grouped are far more effective than half a dozen separate buildings, although each better possibly in individual design, but scattered. Anybody who has the opportunity of noting the effect at Washington, for instance, or the effect in any European cities, realizes the importance of massed public architecture.

Lastly, and most important of all, there is the question of transit. The transportation of the City, particularly its passenger transportation, constitutes the circulatory system of the City—the very life of the City. The problem in all cities is to provide for expansion without congestion, and that is the problem we have to face here in New York. In the vicinity of Sixtieth Street, on the West Side, and of Hester Street, on the East Side, we are housing a denser population than any city in the world permits. Conditions are uncivilized in those sections. Subway transit will take the people out of New York on a low rate of fare and give them opportunities for sunlight and decency outside of the crowded sections. Cheap rapid transit is the solution of the problem of the

slums. Just as the City has grown up by transportation to its gates, so must it look to developing its own transportation if it expects to take advantage of its opportunities. The City will become a civilized city just in proportion as it shall provide adequate transit. In The Bronx it has always seemed to us that the problem of transit consists in continuing the subways right up to the city line so that there shall be only one fare. It would seem unfortunate if the lines should stop after going into The Bronx a short distance only; and is it not a fair criticism to make against the plans as they are at present proposed, that they do so stop and that they are not extended to the north? As regards the Long Island section and the New Jersey section, it seems important that the lines of communication, east and west, should be so organized that transfers can be obtained between lines of transportation north and south on Manhattan Island; that the north and south Manhattan lines should be directly under the surface; that the east and west lines to New Jersey and Long Island should be directly under the Manhattan lines, and that a transfer station should be established at each intersecting point, so that any person coming from Brooklyn or the New Jersey section can transfer north or south on any avenue in New York City, mined by a subway, and that any passenger traveling north or south on Manhattan will have a similar opportunity of transferring east or west on the transverse lines. Again, it seems important that these lines of congested traffic, at least in lower Manhattan, should remain under municipal control. I do not know that I can do better than to read a brief extract from the report of the Board of Trade and Transportation of New York, which will indicate what I mean:

"The fundamental mistake has consisted in treating franchise grants as contracts, unalterable without the consent of both parties, like ordinary contracts concerning property. Governments, like individuals, may properly enough enter into contracts relating to property, and such contracts when made should be respected; but governments ought not by contract to divest themselves of governmental functions as they do to an extent when they surrender partial control of the public streets, by giving to private interests definite term structural rights therein. The City can control completely only when it is in a position to terminate at any time the right of use claimed by any person or corporation that may choose

to defy the will of the City in any respect. In other words, the grant terminable at the will of the governing authorities is the only kind under which the City can be sure of its ability to dominate the situation at all times."

Private corporations are organized primarily for dividends and, in the nature of things, they cannot provide the service necessary for the growing needs of the City. In order to obtain that service, in order to avoid going back to such conditions as prevailed two years ago on the elevated railroad and on the surface roads, the City must itself keep control of its transit system. We think very properly that the City should not attempt to operate at the present time. The City is not prepared to do this nor are the roads themselves organized sufficiently to be taken over. But in order to provide good service, and more important even than that, in order to provide control so as to be able to take care of extensions and improvements and not find ourselves handicapped by what we want to do in the future on account of what we have permitted in the past—the City must keep itself in continual, constant, effective control of the transit grants it gives out hereafter. These transit lines under the great avenues will control not only the future subway traffic of the City, but they will control the elevated and surface traffic as well. To whatever arrangements are made for conducting those lines, other transportation lines will have to conform. If these franchises are given out so that the City can recover them on the payment of indemnity at any time, it will keep itself in control. If the attempt is made to give them out under contractual provisions for extensions, service, etc., the result will be flat failure as heretofore. You cannot hold a public service corporation to a service contract. The only way you can provide for good service and needed extensions is to place the City in a position to take back what it has given and then the City will be able to exert its authority, otherwise its authority amounts to nothing and vanishes in words and legal contests.

The question of the use of the subways by the steam railroads is a very interesting one and is beginning to attract attention among trolley railroad men and among steam railroad men. There is no reason why the subway system of the City should not be used by the trains of the steam roads. It is desirable that the steam road system of the country should have the same degree of elasticity in

collecting and distributing passengers that the trolley system has now, but it is of the greatset importance to the City that if this is permitted the City shall keep control of its transit so that local transit may not be made subordinate to the interests of the steam roads. In the city of London extensive street improvements have been made as a result of the City's taking large areas of adjacent land in addition to the lands actually required for the specific improvement, then making the improvement and selling or renting this excess land after its enhancement in value as a consequence of the improvement and so recouping, in large part, or in whole, for the expenditure incurred. That has been the custom in European cities and I have no doubt we have got to come to it here. The City Improvement Commission have recommended resort to the principle of excess condemnation, and a most opportune occasion can now be found for its application in connection with the acquisition of a court house or other public building site on Chambers Street opposite City Hall Park, the land condemned to include the entire section back of the tall Broadway buildings and between Leonard Street, the Park and Park Row, a section which must soon be reorganized in any event. Why should not the City itself reap the principal benefit of the improvement?

I believe that we will have, at least as regards our transit, to eliminate it from the debt limit restriction. The City is restricted in the amount of debt that it can incur to 10% on the assessed valuation. Water is excepted, but dock improvements should also be excepted and transit improvements should be excepted as well. I notice such conservative organs as the *Record and Guide* are now beginning to advocate that idea.

In regard to co-operation of officials: In the Art Society we have secured co-operation as far as we could get it, and when we did not get it we did not scold too much. We recognized the fact that city officials are limited in three ways,—their term is short to begin with; they have very little money to spend; and lastly there is a natural and very proper tendency towards conservatism on the part of any prominent city official,—a disinclination to try new things. Then they are hampered by the counterclaims of private interests, which seriously interfere with their ability always to do what the City's interest demands. The Society has found it far more

effective to build up a public opinion through the newspapers and through Boards of Trade and local civic associations and by so doing trusting ultimately to overcome opposition.

There are many other things that I could refer to. I should like particularly to go into the recommendations of the City Improvement Commission, but I will not undertake to discuss these here to-night. The hour is late and before closing I will throw a few pictures on the screen in illustration of what I have said.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 20.

PRESENTED NOVEMBER 22D, 1905.

THE PROPOSED MUNICIPAL LIGHTING PLANT.

BY GEORGE F. SEVER,* B. S., M. A. I. E. E.

WITH DISCUSSION BY
MESSRS. NELSON P. LEWIS, J. W. YOUNG, ARTHUR WILLIAMS, DR. CARY T. HUTCHINSON AND HUBERT S. WYNKOOP.

On December 30th, 1904, the Board of Estimate and Apportionment adopted the two following resolutions which constituted the authority for the Electric Lighting Commission, consisting of Dr. Cary T. Hutchinson, Chairman; Mr. Nelson P. Lewis, Secretary, and the writer, to proceed to carry out the instructions of the Board:

(1) *Resolved,* That a Commission composed of the Engineer of this Board, and Messrs. George F. Sever and Cary T. Hutchinson, be appointed for the purpose of preparing and submitting to this Board, at the earliest possible moment, general plans, specifications and estimates for the lighting by the City of public buildings, parks, parkways and streets of the City as a whole and the City by Boroughs, and that this Commission be requested to confer with the Commission of Street Cleaning as to the possibility of utilizing the City waste for the furnishing of the City with power.

Resolved, That a Commission, consisting of the Engineer of this Board, Messrs. George F. Sever and Cary T. Hutchinson, be appointed for the purpose of preparing and submitting to this Board, at the earliest possible moment, general plans and estimates of the cost of furnishing lighting to individual consumers.

*Consulting Electrical Engineer to the Department of Water Supply, Gas and Electricity and Adjunct Professor of Electrical Engineering in Columbia University.

At one of our first meetings, we laid out a general scheme for the conduct of this great undertaking, and fully realizing that much time would be required, by a staff of competent and trained engineers, to carry out all details, it was recommended that the Board appropriate a sufficient sum to meet all preliminary engineering expenses. This was passed by the Board on January 20th, through the following resolutions:

(2) *Resolved,* That pursuant to the provisions of Section 47 of the Greater New York Charter, as amended by Chapter 409 of the laws of 1904, the Board of Estimate and Apportionment, by unanimous vote, hereby approves of the issue of Corporate Stock of the City of New York, in an amount not exceeding Twenty-five Thousand Dollars ($25 000), to provide the necessary means for the payment of expenses in connection with the construction of a Municipal Electric Lighting Plant, for the lighting by the City of public buildings, parks, parkways, and streets of the City, including the cost of preparation of said plant, and that when authority therefor shall have been obtained from the Board of Aldermen, the Comptroller is authorized to issue Corporate Stock of the City of New York, in the manner provided by Section 162 of the Greater New York Charter, to an amount not exceeding Twenty-five Thousand Dollars ($25 000), the proceeds to be applied to the purpose aforesaid.

General Scheme for Carrying on the Work.

(3) An office was obtained and suitable maps of the whole City provided. An office force, consisting of an engineer in charge, draughtsmen and inspectors, whose duties were to collect all data necessary for the Commission, and make the requisite calculations for the reports, was established.

At the outset it was necessary to determine upon the most suitable method of supplying power for the varied uses of the City.

Street lighting forms the largest item of power consumption in the problem, while incandescent lighting comes second. Under the circumstances, both of these can be more readily supplied by an alternating current system than by a direct current one, owing to its general adaptability and ease of regulation.

It is true that this immediately eliminates the security afforded by the use of a storage battery, which is an important adjunct to a direct current system; but provision against shutdown has been made by interconnecting the central stations in Manhattan and Queens and, in addition, running duplicate high tension feeders from Manhattan to each substation in Brooklyn and Queens and from Queens to each substation in Manhattan and The Bronx. By this arrangement, a total interruption of service is made practically impossible.

The following scheme was drawn up and has been made the basis of all work which has so far been done towards lighting the City from its own plants herein referred to.

Power Plants.—Establish three power plants.

1st.—For the entire supply of Manhattan and The Bronx.

2d.—To supply Brooklyn and Queens.

3rd.—To supply Richmond.

All plants to be on the water front. A site in Manhattan is preferable for the first plant, and a site across the East River, sufficiently near the Manhattan plant to permit easy cross-connection, by way of Blackwell's Island Bridge, for the second one.

The Richmond plant will have to be isolated.

All plants to have steam driven turbo-generator units, the generators to be three-phase, 60 cycle, 11 000 volts and a distribution by means of oil switches; the greater part of the auxiliaries to be steam driven, and duplicate exciter sets, and also a storage battery for excitation of A. C. generators.

Substations.—A number of substations are to be established; the buildings to be plain brick structures. Each substation will contain the transformers for operating the series arc light circuits, and constant potential transformers for changing the pressure of a part of the supply from 11 000 to 2 200 volts; also distributing boards for the single-phase branch feeders from the substations to the various centres of distribution. These substations will also be used as depots for supplies, headquarters for trimmers, etc., for the adjacent district.

Centers of Distribution.—Each center of distribution will contain constant potential transformers, changing the pressure from 2 200 to 230 volts for the incandescent lights and motors to be

supplied from that center; also, the distributing loads for the low tension circuits from the center. These centers will be located in the larger buildings to be lighted, the smaller buildings in the immediate vicinity being fed therefrom by three-wire 230-volt feeders. The apparatus in each center will be installed in a vault under the sidewalk in front of the building, or in a small brick enclosure within the building.

Feeders.—To each substation will be run a three-phase 11,000-volt feeder from each main station; from each substation will be run the feeders for the arc lights and 2 200-volt single-phase feeders to the centers of distribution for the incandescent service. From the centers of distribution will be run 3-wire single-phase circuits to the smaller buildings.

The small motors will be run from the single-phase circuits; for the larger motors, of which there are very few, three-phase circuits will be provided.

The system of distribution has been designed for the close regulation that is necessary for good service; to secure this we plan to regulate the pressure at the transformers in each substation, either automatically or by hand.

Division of Work.—It was decided to divide the work the Commission was appointed to do into six reports as follows:

(*A.*) Report on the cost of construction and operation of an electric plant to supply all the streets and public places of the Boroughs of Manhattan and The Bronx that are now lighted by electricity, and to light all the public buildings by electricity that are now lighted by either electricity or gas, or by both.

(*B.*) Report on cost of construction and operation of a plant to supply all the electric lighting included under (*A*), and in addition, to substitute lighting by electricity for all other kinds of lighting in the streets and public places of the Boroughs of Manhattan and The Bronx.

(*C.*) Report on the cost of construction and operation of an electric plant to supply all the streets and public places of the Boroughs of Brooklyn and Queens that are now lighted by electricity and to light all the public buildings by electricity that are now lighted by either electricity or gas, or by both.

(*D.*) Report on the cost of construction and operation of a plant

to supply all the electric lighting included under (*C*), and in addition to substitute lighting for electricity for all other kinds of lighting in the streets and public places of the Boroughs of Brooklyn and Queens.

(*E.*) Report on the cost of construction and operation of a plant to do all the public lighting of the Borough of Richmond by electricity.

(*F.*) Report on the cost of construction and operation of all the City's lighting, assuming the City to own transformers, wires cables, poles, lamps and other appliances, and to purchase electric power in the several boroughs from such sources as may be available.

On February 10th, 1905, Report "A" was submitted to the Mayor, with the recommendation that the City secure sites for power houses in Manhattan and Queens, and stating that plans and specifications for the central station and other work incidental to the plant were being prepared.

REPORT "A."

This report was based on the report made to the Commissioner of the Department of Water Supply, Gas and Electricity by Cary T. Hutchinson, dated May 11th, 1903. The estimates contained in that report and the data on which these estimates were based, was checked.

Under this estimate it was found that a power plant capacity of 10 000 k.-w. was required to supply 6 000 arc lamps and a connected load equivalent to 250 000 16-c-p. incandescent lamps. The total cost of the power house substations and distribution system was found to be....	$4 100 000
The cost of operation per arc lamp.....	$75.40
Cost per incandescent lamp service per Kw-hr.	5.15c.
Total cost of operation.....	$906 000

The estimate includes neither the cost of construction of ducts for cables, nor rental charge for duct space, as the Corporation Counsel has informed us that the City has the right to use all duct space that it requires, free of charge.

Report "B."

Report "B" was submitted on June 19th, 1905, and contains the plans and specifications of the power stations which are the same for Manhattan and Queens.

Between the submission of Report "A" and Report "B", $600 000 had been appropriated for power-house sites in Manhattan and Queens and the same had been purchased.

This estimate which includes the lighting under "A" and in addition the replacing of all gas, naphtha and other illuminants, in the streets of Manhattan and The Bronx, by electric lights, provides for a power-house of 15 000 k.-w. capacity and a distributing system designed to supply 15 000 arc lamps and 300 000 16-c-p. incandescent equivalents, at a total cost of $7 567 000.

The total annual operating and fixed charges are $1 269 000. The proposed plant would effect a saving, based on the prices in effect before the passage of the recent law reducing the price of electric power and light, of $434 000.

Report "C."

This report covers the Boroughs of Brooklyn and Queens on the same basis as "A" covers Manhattan and The Bronx. It was found that a plant of 10 000 k.-w. capacity would be necessary and a distribution system designed to supply 7 500 arc lamps and 200 000 16-c-p. equivalent incandescents, at a total cost of $6 138 000.

The total operating and fixed charges would be $845 000 or $27 000 more than it would cost to obtain service for the same number of lamps from existing sources of current, under the new prices.

It should be remembered in this connection, however, that the service contemplated in this report is superior, both in quality (electricity being substituted for gas in all buildings), and candle power, to that now furnished the City. And also, that the estimate covers the cost of a conduit system consisting of 156 miles of trench, principally located in the central part of Brooklyn where it is desired to place no additional overhead wires.

Also, that the cost of incandescent service is high, the lamps only burning on an average of 200 hours, as compared to 373 in Manhattan and The Bronx.

Report "D."

This estimate which includes the lighting under report "C" and in addition the replacing of all gas, naphtha and other illuminants, in the streets of Brooklyn and Queens, by electric lights, provides for a power-house, of 15 000 k.-w. capacity and a distributing system designed to supply 15 000 arc lights and 200 000 16-c-p. incandescent equivalents. The total cost will be $9 485 000.

The total annual operating and fixed charges will be $1 424 000. The annual cost per arc light will be $76.89 and the cost per kilowatt for incandescent service will be 13.53 c.

Taking the exact number of buildings and street lamps connected on December 31st, 1904, as a basis of comparison, the annual cost of the City lighting for the Boroughs of Brooklyn and Queens, from the proposed plant, would be $68 000 in excess of the cost under the rates fixed recently by the State Legislature.

It should be borne in mind that, as the territory to be lighted becomes more thickly settled, the annual cost per arc lamp and kilowatt-hour of incandescent service will decrease.

Report "E."

The report for the Borough of Richmond has not yet been completed, but sufficient data has been collected to show that it will require a plant of between 1 000 and 1 500 k.-w. Most of the street lighting in this Borough is now done by electricity, and the building lights are found to burn on an average of 120 hours a year.

Report "F."

Report "F" covers the ownership, by the City, of all transformers, wires, cables, poles, lamps, and other appliances, and the purchase of power in the several Boroughs from such sources as may be available. This report has not yet been written.

Duct Situation in Brooklyn.

In a certain portion of the Borough of Brooklyn, known as "the restricted area," which is bounded by East River, Hamilton Avenue, 15th Street, Prospect Park West, Eastern Parkway, Albany

Avenue, Fulton Street and Broadway, it has been decided not to allow any additional overhead construction to be placed and therefore, as the City has not the right to use existing underground construction, for the purposes of this plant, it was necessary to estimate upon the cost of a duct system in this territory.

In Report "C" the cost of this duct system amounted to $1 414 000, and in Report "D" to $2 226 000—which to a considerable extent accounts for the higher estimated cost for lighting the Borough of Brooklyn. This duct system includes ducts for main feeders partly outside the "restricted area."

Summary.

Briefly referring to the foregoing, it will require an investment of $10 238 000 to light the four Boroughs of New York City, other than Richmond, in accordance with the conditions under Reports "A" and "C," and $17 052 000 to light them as outlined in Reports "B" and "D."

There will be a saving in the cost of lighting, even under the new rates passed by the Legislature, considering Reports "A" and "C" of $301 000; and taking Reports "B" and "D" of $360 000; or taking Manhattan and The Bronx alone, Report "A" will save $328 000 and Report "B" $427 600.

A Municipal Lighting System for the Boroughs of Brooklyn and Queens, similar to that provided under Report "C" will make the cost of lighting $27 000 greater than under the ruling rates. One similar to that in Report "D" will make the cost $68 000 greater than under the ruling rates.

Conclusion.

In closing, the speaker desires to express to those members of the Municipal Engineers of the City of New York and all engineers in the employ of the City who have been called upon to give assistance to the Commission and its engineering staff the grateful thanks of the Commission on Electric Lighting, and to record the fact that in all directions the representatives of the Commission were accorded the utmost courtesy in their search for the information desired.

DISCUSSION.

NELSON P. LEWIS, Member of the Society.—My position on this Commission is of a connecting link between the two expert electrical engineers who are my fellow members and the Board of Estimate and Apportionment. There were some practical problems confronting the Commission that may be of interest to you.

We have secured, and the City now owns in fee, the sites for these plants; and it was necessary to conduct the negotiations for their acquisition very discreetly, so that it was not until after the sites had been secured and the title was vested in the City that it was generally known that we wanted land for this purpose. Some time afterward a gentleman came to me to talk about sites and he offered us a site which we had already bought, at a price $200 000 more than we had paid. In other words, the Commission has done its work quietly. We have seen very little about it in the papers, but you will, I think, appreciate that a very large amount of work has been done. The organization of this force and its efficiency has been due to the technical knowledge and the executive capacity of the Chairman of the Commission and Professor Sever, and the industry and capacity of Mr. J. W. Young, who has been in immediate charge and whom we have with us this evening.

The site for the plant for lighting the boroughs of Brooklyn and Queens is just south of the Queens end of the Blackwell's Island Bridge, about at the foot of Nott Avenue. It is considerably larger than that acquired for Manhattan and The Bronx; so that we will have plenty of room for enlarging the plant when some of the dark areas of Queens are built up and require lighting.

No reference was made by the author of the paper to one clause of the resolution which he read to you, namely, that the Commission was instructed to consider and to confer with the Department of Street Cleaning as to the utilization of City wastes for fuel. The Department of Street Cleaning, as you know, has established a couple of plants in Manhattan, one on the North River, which is and has been doing some lighting, and recently a plant to light the Williamsburg Bridge has been installed, and it is expected that it will also supply current to light several school buildings in the neighborhood. The Commission has been disposed to be conservative in considering this problem, and while small plants are undoubtedly very successful, it was a very serious proposition to think of collecting the combustible wastes of the City at one central point. The cost of transportation would be enormous, and if you have seen the way the wastes are handled and sorted, you can realize it would require several City blocks in addition to that occupied by

the plant. I think that had it been seriously proposed to buy two or three City blocks in Manhattan, in the neighborhood of Ninetieth Street and the East River, to be used for such a purpose, there would have been a howl of protest from that neighborhood.

J. W. YOUNG, Esq., Engineer to the Commission.—It may be of interest to the members of this Society to know the manner in which the data necessary for the reports of the Commission were obtained and how the results, described by Professor Sever, were secured.

Collecting Street and Building Light Data.—In order to design the system of distribution necessary to supply the street and building lights, the location of these had first to be obtained. The available records of the Department of Water Supply, Gas and Electricity of this City were checked and brought up to date. Inspectors were then sent through every public building in regard to which additional information was required and a tabulated list made of the number and character of the gas, electric light and power equipment in each room. Men also covered the streets to locate the different kind of lamps where necessary. This work took several months.

The street and building lights and the location of the buildings were then plotted on large scale maps, copies of which are here to-night, for each borough; the building lights being reduced to 16 c.-p. incandescent equivalents.

Calculating Building and Street Light Circuits.—From the number of lights thus shown on the map the distribution of the load was evident and the location of the main power-house was obtained, and the number and economical location of the substations determined; due consideration being given to the probable development of the territory.

Street circuits were laid out and their cost estimated, each being designed to carry the equivalent of fifty 2 000 c.-p. arc lamps and two mains placed on each highway, the lamps being connected alternately on these conductors, so that if one circuit should be in trouble, half of the street lights would continue to burn.

The size of conductors, transformers, etc., were then calculated for the building lights, each group of structures being carefully considered, and the economical center of distribution located in one of the larger installations, which point was fed from the main substation by 2 200-volt single-phase feeders; the smaller bunches of lights being connected to a center by three-wire single-phase conductors.

All the building lights were thus connected to distributing points, except those in the immediate vicinity of the substation. Street lights were fed from the substation proper.

It was decided to place the 11 000-volt three-phase feeders, the 2 200-volt feeders, where on the same street, and all wires in public

parks, underground; in all other places, except in Manhattan and the "restricted area" of Brooklyn, overhead construction was decided upon.

Pole lines were therefore required and a complete conduit system in the "restricted area" and also for the main feeders. It was assumed that existing overhead equipment could be attached to by the City after proper rebuilding, at its expense, and upon payment of a yearly rental.

Every street was gone over and a record made of the overhead lines. Also a map showing in detail the location, as to side of street and ownership, of all the underground conduits in Brooklyn. A large amount of data on the cost of conduit construction was obtained independently from two of the principal contractors in the United States, which checked very closely and this was utilized as a basis for calculating the conduit plant. The record of existing underground conduits being especially valuable in placing the heavy runs so as to avoid existing systems.

The cost of reconstructing the pole lines was then worked out and the rental charge, also the expense of building new lines, where none existed.

Poles.—On the principal streets of Manhattan the present iron poles were duplicated. On the other streets of Manhattan and the other boroughs, poles of a somewhat different character were provided, equipped with mast arms to bring the lights more out in the streets and away from the sidewalks. This is particularly desirable in The Bronx and places where the foliage interferes with the illumination from lights placed along the curb.

Where lamps would be attached to pole lines a mast arm was used. Prices for this material were obtained from a number of manufacturers and the total cost calculated.

Service Connections.—The cost of making service connections from the streets to the centers of distribution and other buildings, both underground and overhead, was worked out together with the cost of connecting the street lamps to the underground conduits and pole lines.

Power House.—The next problem taken up was the calculation of the size of the load for which it would be requisite to provide equipment in the power-house. In order to obtain the proportion of the maximum load to the total connected capacity, recording watt meters were installed in a number of public buildings and calculations made from the bills for the entire lighting of the City, in every borough, from which were derived the average number of hours burned by gas and electric lamps.

The maximum equipment necessary in the main power-house was thus derived and after a thorough comparison of the different types of power-houses, now in use, and the collection of a large

amount of data as to the cost of machinery, the cost of a generating system was estimated.

Yearly Charges, City Rates, and Municipal Plant.—To compare the cost of lighting in the various boroughs, under the municipal plant, with the rates charged the City, the cost of lighting was estimated partly from meter readings where bills had not been rendered and partly from bills made out according to the rates charged up to December 31st, 1904.

An estimate also was made of the cost of City lighting under the recent Act of the Legislature. The exact number of lamps on a certain day was taken and a comparison between the above prices and the unit prices made for each report of the Commission.

The above in a general way describes the manner in which the work of the Commission was done.

ARTHUR WILLIAMS, Esq., General Inspector of The New York Edison Company.—Lighting the streets of a municipality is a commercial question. There is no sentimental reason for or against the manufacture of light by the municipality, for or against its purchase from a private corporation. The consideration is one of relative cost and of service standards.

Service standards are of even greater importance than cost. One of the essentials in a modern, well-governed municipality is good light continuously supplied. Police Commissioner (now President) Roosevelt once said that an arc lamp was equal to a policeman. In New York an arc lamp costs $100 a year; a policeman twelve times as much.

Were the service poor, the City would be compelled to employ all necessary means, at whatever cost, to improve it. This, however, cannot be a question here, for the lighting standards of our City are generally recognized as the highest in the world.

No street lighting was ever subjected to a severer test than that of New York on the day and night of the blizzard, occurring in the early part of this year. It will be remembered that such trains as succeeded in getting through (very few did) consumed from ten to fifteen hours between New York and Albany. The street car system was compelled to suspend operations, cars were abandoned on every hand, and yet not a single street lamp failed to give the usual service. During the storm a prominent city official made a personal inspection of a great many streets, and reported every lamp burning brilliantly.

Insurance against Interruption.—Still another question may enter into the problem: Assurances against interruption from transportation troubles, the weather, or other causes. Would such assurances be of a more substantial nature were the City itself to manufacture the light it requires?

Here it should be pointed out that, saving large expenditure, the

Engineering Commission fails to include anything like the coal storage capacity of the private companies. The New York Edison Company, in addition to carrying many thousands of tons in each of its generating stations—the bunkers of one station containing 15 000 tons—has provided a storage on the New Jersey shore of the North River of from 200 000 to 300 000 tons. From here coal can be taken in barges and delivered directly into the Company's principal generating stations. The supply is sufficient for two-thirds of a year, a period much beyond the possible duration of any interruption in the source of supply.

A Cheap and Inadequate System Adopted.—The Commission is composed of engineers of the highest technical standing and one should, therefore, hesitate in criticising the plans adopted. Yet the system proposed is not equal to and does not give the assurances of the present system.

It is understood that the change is made to secure a cheaper method than that used by the private companies. For example, it would not be possible to use storage batteries, without the aid of which the best service cannot be maintained, and, in fact, without which no system supplied from a high tension generating station can be operated without constant probability of interruption.

It does not seem fair to compare a system which, at enormous cost, has been developed to provide these advantages with one, which to obtain cheapness, omits them. The comparison is not "on all fours."

Present Street Lighting not Expensive.—The cost of illuminating our streets is extremely low. For such illumination as we see around us on every hand, of an average unequalled in any other city, the per capita cost for each resident of Manhattan Island is less than $1 yearly. It is about two-tenths of a cent daily. A 1-cent tallow candle burned nightly for each resident would increase the present cost of municipal lighting fully five times.

It is repeated that the comparison should be made between systems of like efficiency giving equal standards of illumination and equal assurances of continuous service.

The Omission of Taxes.—One must disagree also with the views of the Commission that the loss of taxes should be omitted from the operating cost of this plant. Almost without exception, curiously, taxes lost are omitted from all municipal ownership calculations. Advocates of municipal ownership, basing their premises largely, if not entirely, upon the expected, and in practice, imaginary profits to be derived from the enterprises, give little heed to the value of the taxes paid by private corporations.

Essentially there is no difference between such taxes and profits, real or alleged, from municipal ownership. From the operation of the street railways the City of Glasgow last year received in the

form of "profits," so-called, less than one-sixth the amount paid in taxes by the rapid transit companies of the Borough of Brooklyn alone, and the population of the two is about the same. In the same period, Great Britain, the home of municipal undertaking, received less from all her municipal street railways than the aggregate taxes paid alone by the street railway corporations of our own State of New York. And to achieve their results the British municipalities were compelled to invest $140 000 000 of the taxpayers' money; the State of New York invested not 1 cent.

A Fair Example of Municipal Ownership.—Freiburg, the so-called "Model City of Germany," where everything from the gas and electric light works to pawn shops, cemeteries and building lots, is owned by the municipality, received from the operation of the gas and electric light works and the street railway system last year, $10 359.99, or less than 2%, which is called a "profit." In taxes alone, in similar enterprises, American companies would have paid more than $50 000. Had Freiburg received such a sum from these enterprises, one can imagine what a stir would have been created throughout the civilized world, and yet, paid by private corporations, it is not taken into account.

Curiously, what seems to have been real profits at Freiburg were made from the cemeteries and water works. These are two of the absolute necessities of our daily life and they should be obtained by the public at the smallest possible cost. Yet out of $147 676.00 received from the two departments in charge of these matters, $84 755, or 57%, were reported as net profits.

This result is but another indication that municipalities are not able to manage such technical industries as gas and electric light, railways and telephones that require administrative and professional skill of a high order.

Underestimated Operating Costs.—The Commission estimates that the mere operating cost of an arc lamp, including labor and fuel, are approximately $35 annually—not including interest or depreciation.

For labor alone the cost of operating the municipal lighting plant which now supplies the old Brooklyn Bridge is in excess of $50 annually for each arc lamp supplied. This figure was obtained from the *City Record*, in which are itemized the expenditures for labor.

The Commission states that the nine small electrical plants now operated by the municipality in the Borough of Brooklyn cost annually $100 000. But the same, or better, service would be rendered to the City by the local electric light company at a cost not exceeding $70 000.

The largest municipal street lighting plant in the world is that of the City of Chicago. For a long time the City authorities have

claimed that it is operated with great economy, and yet the report for 1904 states that the operating cost of an arc lamp was $54.36, or $20 more than the Engineering Commission allows for operating costs in this City. The Chicago figures do not include water, amounting to approximately $4 annually for each arc lamp. Furthermore, relative expenses are much greater in New York than in Chicago.

Depreciation.—Another point at issue is the allowance for depreciation. This was originally placed at 7½% by the distinguished chairman of the Commission. But more recently the Commission has reduced the figure to 6 per cent. Within twenty years The New York Edison Company has changed its generating system several times and another change is now in sight. The lowest expenditure estimate of the Commission is now $7 567 000 and the annual difference between these percentages—6% and 7.5%—amounts to $113 505.

The Commission's Report.—The report of the Commission as thus far submitted, has been divided into four sections—A, B, C and D. A and B refer to Manhattan Island and The Bronx; C and D to Brooklyn and Queens.

A and C give the cost of substituting the present electric street lighting, now privately supplied and the electric and gas lighting of public building, with municipal service; B and D give the cost of substituting electric light wherever gas is now used—on the streets as well as in the public buildings.

Reports C and D (Brooklyn and Queens) admit $100 000 annual loss. Little need be said about either C or D, as they admit a loss of almost $100 000 annually were the City to replace the present service with that of a municipal plant. And many items are omitted, which, if included, would increase the loss to more than $250 000 annually. According to the Commissioner's estimate, the City must make an investment of $9 485 000 to accomplish this result.

Report A, the first submitted, calls for an investment of more than $4 000 000. It admits operating expenses of $892 000 for a service that can now be purchased from the private companies for $650 000, or at most $700 000. This section, therefore, need receive little further attention.

It is Section "B" in which we are more directly interested. It calls for an investment of $7 567 000 and claims an annual saving of $434 000.

The report does not include the cost of subways, which would be not less than $3 750 000; it does not provide for the equipment with wires and fixtures of the buildings now using gas; nor for the changing of the present electrical apparatus, including elevator and other motors. On a conservative basis this equipment would cost,

including, properly, engineering expenses, not less than $2 750 000. Thus the ultimate investment by the City through the introduction of a municipal generating plant would be $14 067 000 to obtain a so-called "profit" of $434 000—about 3%.

But there would be no such differences as $434 000. The entire cost of lighting the City last year was $1 703 000. It is upon this basis that the foregoing hypothetical "profit" is obtained by the Commission. The legislative reduction in the price of street arc lamps lessens this sum by $204 000; the reduction in incandescent lighting would lessen it from $15 000 to $20 000 more, and there has also been a reduction in the price of public gas lighting. But allowing only for the change in the cost of arc lighting the total margin claimed by the Commission becomes reduced to $230 000, hardly more than 1½% on the ultimate investment.

Items of Cost Omitted.—Here, again, however, we find items omitted. There is no allowance for taxes lost, which amount to approximately $80 000 annually; no allowance for general expenses, executive and administrative, which for a plant of this size would amount annually to not less than $75 000; there are no changes incidental to the installation expenditure—$2 750 000, upon which must be allowed 10% annually or $275 000; likewise, all subway costs are omitted, which, on the basis of 10% for interest, depreciation and taxes, would be $375 000; there is no allowance for the unkeep of the underground cable system, which would average not less than $2 annually an arc lamp, or $30 000 altogether; the Commission allows the absurdly low figure of $8 annually for unkeep, maintenance, repairs and attendance for each arc lamp—yet no private company can render this service for as little as $12 annually; adding the additional $4, we must again increase the expenses of operating the municipal plant by $60 000.

The aggregate of these additional items is $895 000, making an annual net loss to our taxpayers of $655 000, instead of a gain as reported by the Commission of $434 000. This loss would be made up by additional taxation.

A *résumé* shows: (A) no reason whatever from the standpoint of quality of service, for changing from the present system; but from the standpoint of assured service every reason for continuing it. In fact, in regard to both, the City is far better off than were it to adopt the plan of the Commission. And finally (B) there is no financial reason for a change. Not only would the City make no profit from the operation of the plant, but it would unquestionably place itself in a position to lose large sums annually, aggregating hundreds of thousands of dollars.

Such considerations as to the addition of a large, complicated department, with a great increase in the number of municipal employees, and a widened field for political corruption, while important

and perhaps predominating, have not been referred to as a factor in presenting the foregoing conclusions.

DR. CARY T. HUTCHINSON, Chairman of the Commission.—I have very little to say in reply to Mr. Williams' remarks. Some of the figures he gives are correct; others, I think, are exaggerated. The matter of lost taxes is purely a question of the point of view. The taxes assessed against the Edison Company would not be changed in any respect by the operation of the City's plant and the City would lose no taxes save those on the real estate occupied by the plant.

Mr. Williams adds a large amount to the estimates for wiring of buildings; this is not a charge against the City plant, but is a charge against the change from gas lighting to electric lighting and would have to be paid whether the buildings were supplied by the Edison service or by the City plant.

In our opinion, 6% depreciation on total costs, excluding real estate only, is sufficient, for a plant built at this day and of the most modern description. The total costs shown by the table are very liberal, and I have no doubt that the plant can be built for these figures, or less.

The City claims the right to use ducts free of charge, and has brought several suits, which are now pending in the Courts, to enforce this right; but of course it is impossible to predict the outcome.

When we were ordered to make these reports, the City was paying $146 per arc lamp; hence the saving shown in Reports A and B is very large; the Legislature has since reduced the price to $100, and the savings to be made by a City plant are consequently reduced considerably. This whole matter will be summarized in an additional report which I hope to present soon.

HUBERT S. WYNKOOP, Member of the Society.—I have very few ideas on the subject of municipal plants, but those few ideas are very strong, and, perhaps, I may be permitted to call attention to just one. You cannot use automatic stokers, for instance, for voting purposes; therefore there will always be a tendency on the part of some persons in authority to discredit the stokers in order to enlarge the pay-roll. For this reason I am opposed—and this is my personal engineering opinion—to a municipal plant until such time as our municipal methods have advanced beyond their present stage and have reached a point where the cost of municipal operation can compare favorably with the cost of operation by private capital.

In the private plant of to-day each Superintendent of Division is held responsible for results and is allowed to appoint and discharge his subordinates. On public work the engineer has to do the best he can with the force placed at his disposal.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 21.

PRESENTED DECEMBER 27TH, 1905.

THE HISTORY AND DEVELOPMENT OF THE PLANE TABLE.

BY EDWARD M. LAW, JR.*

WITH DISCUSSION BY
C. M. BERNEGAU, S. C. THOMPSON, R. R. CROWELL, M. L. FOUQUET, G. W. TUTTLE, M. H. LEWIS, H. K. ENDEMANN, E. H. THOMES, H. I. LURYE, CAMILLE MAZEAU, J. T. METCALF, ERNEST ANKENER, AND THE AUTHOR.

The paper I have to present to you to-night is one of great interest to all municipal engineers, and of special interest to the topographical engineers in general, a large proportion of whom are members of this Association and are with us to-night.

The critical topography of our great cities, forming as it does a basis for all construction work and for public improvements in general, is a subject of vast importance to us all. Greater New York, in particular, with its newly acquired territory of over 265 square miles is bending all its energies in this direction toward the mapping of this for the most part open and undeveloped country. The problem naturally presented itself at the outset as to what was the quickest, best and most economical means of obtaining the topography of this vast and unmapped area.

To Queens Borough belongs the credit for first introducing the plane table method of mapping the topography of Greater New York. The anticipated rapid development of this borough necessi-

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tated the adoption of some quick means of getting the required information for its topographical maps. Other methods having been tried with varying success, the plane table method was recommended by Mr. Ernest Ankener, the Principal Assistant in the Bureau of Topography, Borough of Queens, and was introduced in that field by Mr. Robert R. Crowell, Engineer in Charge of the Topographical Survey of that Borough.

To those who are familiar with its use on that work, where it was my privilege to operate one of the first tables there used, it needs no further demonstration of mine to convince them of the practical utility of the plane table method of mapping topography —all are united in its praise. The results obtained, and the large and carefully mapped area already covered in that borough, are a practical demonstration of the superiority over others of the plane table method on the critical topography of large scale municipal work.

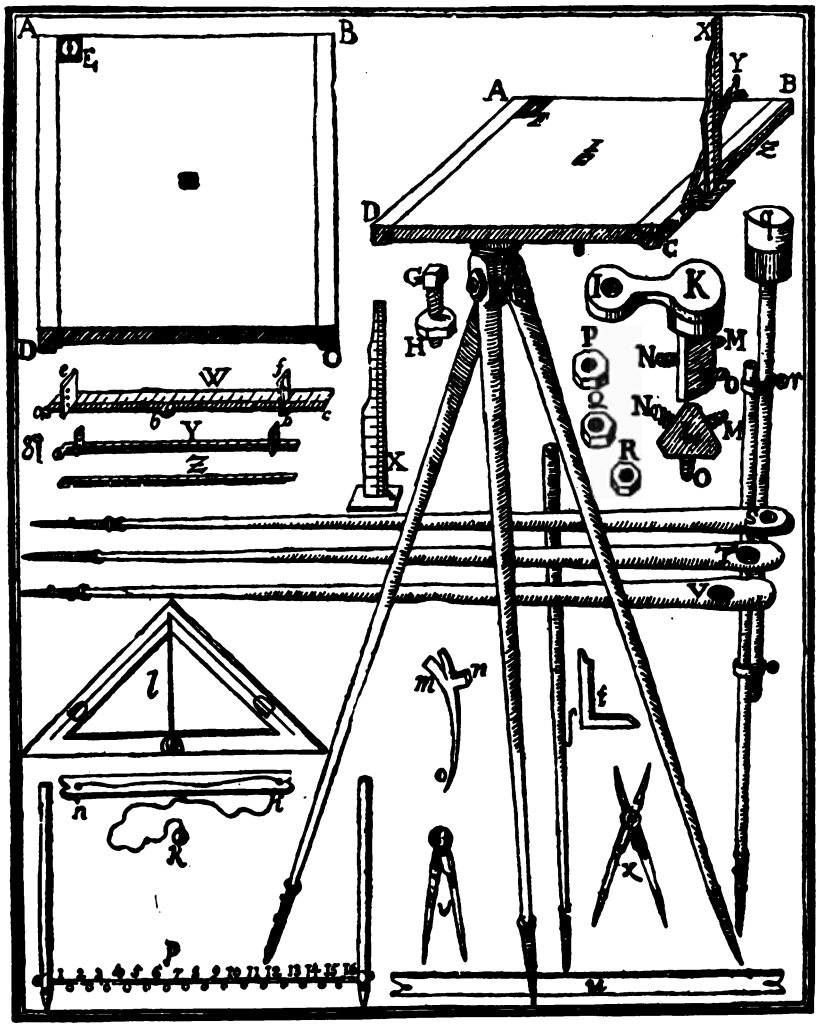
This advance step of the plane table and stadia method over the transit and stadia method on this class of critical municipal work is a practical illustration of its universal value as a mapping instrument.

Adopted by our Government on the small scale work of the United States Coast Survey, and universally used throughout the greater part of Europe, old topographers are enthusiastic in its praise.

Before describing it in its present perfected form, it is well to look into its history and its gradual development to the modern plane table that we know and use to-day.

The invention of the plane table is ascribed to that famous mathematician, Prof. Johann Prætorius, of Altdorf, in 1590. Again, in a description of old Würtemburg Forest Surveys by Regelman (1680) it is referred to as the "Nurnberger Geometric Table" or as the "Plane Table of Prætorius." It was then known as the "Prætorian Mensula" (Plate LVII). This crude instrument has many parts which in their rough state may be recognized as identical with the plane table of to-day, in which the telescope replaces the peep-sights, and the vertical arc takes the place of the rules on the side of the original table which were used to measure the horizontal and vertical components, as vertical circles were not then in

PLATE LVII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAW ON HISTORY OF THE
PLANE TABLE.



DIAGRAMS ILLUSTRATING DESCRIPTIONS OF THE PRÆTORIAN MENSULA (THE ORIGINAL PLANE TABLE), IN M. DAN'L SCHWENTER'S "GEOMETRICÆ PRACTICÆ," NÜRNBERG, 1667.

use. The Mensula is therefore known to be the first plane table used, and this in the 16th century.

The advance has been gradual since then, the improvements keeping pace with those of the transit and theodolite. The Germans and French were foremost in making additional improvements on the plane table, and it was quite universally used in these countries.

Another South German Geodetist, Schickhardt of Wurtemburg (1529-1635), referred to the plane table principle substantially as follows:

"He who in traveling has not a plate divided into degrees with him, or being pressed for time does not wish to use a compass, could, in necessity, without the use of any instrument obtain the object by the following means: He simply fastens a piece of paper onto a small board or plate, and sets the board immovably down; after this sticks a pair of needles on a ruler, sights therewith on the towers, and passes all lines from one point."

The above naïvely described principles of the Plane Table are perhaps over 2 000 years old. Is it not possible that the Euclidian principles of the similarity of triangles were established by way of Plane Table drawing?

"A Geometrical Practical Treatise named Pantometria, divided into three Books, Longimetra, Planimetra, and Stereometria," by Thomas Digges, Esq., was printed in London by Abell Fesses in 1591. This work is a revised and enlarged edition of a work published in 1571 by the same author, being the completion of a work commenced by his father, Leonard Digges, who died a short time previous to the publication. In this 1591 issue are contained the following notes not found in the 1571 edition:

"There are many other Inventions also and Mechanical rules taught by Italians and some Germans without any Geometricall Instruments to measure the Altitude of Towers, the breadth of Ditches and Distance of Markes and in the Field upon a Drumme head to make Plattes, and set downe the proportion of anye Sconces, Fortes, Bulwarkes, or Townes, yee shall approache the fiew of, but they are meanes so uncertaine and so subject to error upon any small mistaking as I hold them utterly unworthie to be coupled with these Propositions, which are all in the highest degree of certaintee confirmed with invincible demonstrations Geometricall, only I meane

to give a breefe Note of one kinde of plaine Instrument and so close up the first Booke of this Geometricall Practize.

"Some take the Semicircle of my Topographicall Instrument, setting the Perpendicular thereof upon a straighte long Rular divided into a thousand or more equal parts, and instead of the Horizontal Circle use only a plaine Table or boarde; whereon a large Sheete of Parchment or Paper may be fastened. And thereupon in a fayre day, to strike out all the angles of Position, even as they finde them in the Field without making computation of the Grades and Scruples.

"Or if you list to describe any Wood or the Circute and Proportion of any other place, where yee cannot beholde the whole or the greatest parte at once, ye may with this plaine Instrument beginne at anye one pointe where yee list.

"And directing the sights of the semicircle to the nexte pointe or angle so farre as yee may goe in a right line by the Subjacent ruler drawe out the line of position, and measuring how manye score, or Paces or Perches by the answerable Scale; to pricke it out on the paper accordingly, as hath beene shewed already at large in the 34th chapter.

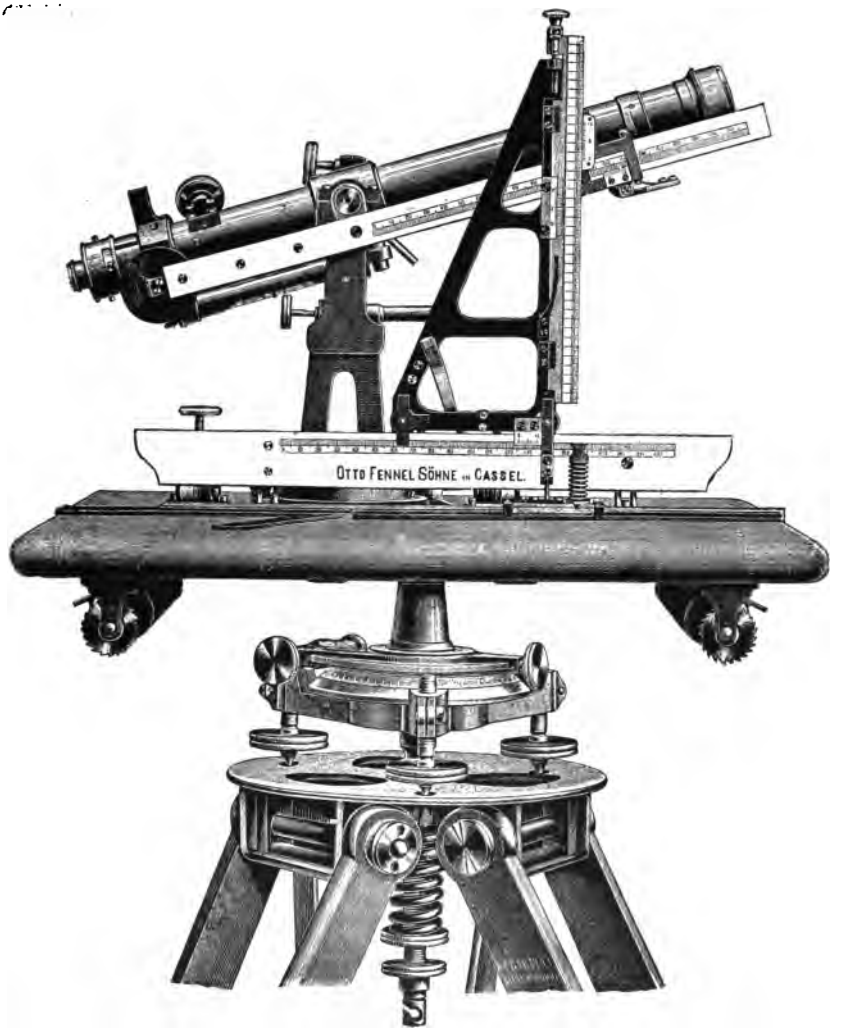
"In this manner yee may proceede on from Angle to Angle setting downe still as you goe upon the Paper, the perfect Platte thereof: But of one thing I think fitte to admonishe you, that you must in this kinde of Platting proceede wonderfull warelye, for if you erre never so little in the severall stations, when yee come to close uppe the Platte, you shall finde a great and apparent Error.

"But by practise as yee finde the inconvenience thereof, yee shall also learn by crosse Angles of Position to examine and rectifie those errors wherein I spend the lesse time because it is nowe so usuall and the reasons of the Premisses well understanded will well cleare all doubtes in this rude and plaine kinde of measuring."

These early surveys were for a long time of very questionable precision and it has not been until within the last century that closer and more precise work has been made practicable. The main purpose of these earlier surveys having been that of obtaining some knowledge of newly acquired territory, virgin fields as yet unknown and untrodden by man, the surveys of that day may well be designated as much in the nature of reconnaissances, and indeed were limited to attaining sufficient data for the location of rough military roads for moving artillery and troops in the conquest of additional territory.

The increasing population of these countries demanded more

PLATE LVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAW ON HISTORY OF THE
PLANE TABLE.



THE TACHYGRAPHOMETER.

critical surveys, obtaining more definite knowledge of the country, as a basis for public improvements.

The Plane Table has proved to be the best method for filling in the topography, as its universal use on the Continent and throughout the United States has demonstrated. The plane table method has been used in France since the beginning of the 16th century. It was early used in military reconnaisance on the border lines. Its use is now general throughout France.

The Graphic Triangulation by plane table is conducted under the direction of the Geographic Service of the War Department. These tables have a ball and socket head, of heavy build, and tachymeter readings are taken separately and afterward plotted on the plane table sheets, the scale being $\frac{1}{20000}$ in mountainous, and $\frac{1}{10000}$ elsewhere. The plane table is oriented by compass as used on both of these scales, and the detail work is filled in directly by the plane table method. These scales are the same as are now in use by the United States Coast and Geodetic Survey.

In Germany it has been much longer in use. Many and diverse are the patterns invented and put in the field by these enterprising people, who were the first to recognize its efficiency. In Baden contours were first used for the delineation of the terrene in 1825 to 1846. The Germans are very thorough in representing the topography of the German states. The plane table sheet as used there is 17 by 20 in., and is furnished with 25 or 30 triangulation points, whose elevations have also been previously determined in the progress of the triangulation. The arenoid measurements are largely used in connection with the plane table on preliminary work as based upon spirit level runs.

The Tachymetric Plane Table is largely used in Germany, principally in the northern part. It is otherwise known as the Tachygraphometer (Plate LVIII). This method consists of a mechanical reduction of the horizontal and vertical components obtained by a single pointing of the telescope at the rod, the position and elevation of the point being recorded on the plane table sheet by simply "pressing a button." The point as plotted is therefore as mathematically exact as the graduation on a machine-divided plate, and as free from human error. Skilful topographers using this method

on small scale work have reported 600 to 700 points plotted on the sheet in a working day of ten hours; this work being done by the topographer and one assistant.

In the southern States of Germany, in Switzerland, and in Austria, the method of barometric readings, with corresponding observations by plane table, is used. This work is based throughout on spirit leveling and on a network of primary triangulation divided into triangles of the second, third, fourth, and fifth order.

In Italy a very complete instrument is used with the plane table. The differences in elevation are computed at the station, the distances being obtained by stadia measurements. The field work is done entirely by means of the plane table. The contours are 10 m. intervals on the $\frac{1}{50\,000}$ scale, and 5 m. apart for the $\frac{1}{25000}$.

In Austria, contours are run by barometer and plotted at once on the plane table sheet by placing the rodman on the contour and noting the reading of the aneroid. He holds this reading and travels along the contour, telemeter readings being taken to the points he selects at each noticeable change in its direction.

The early topography of our own country was obtained in rude fashion with the crude instruments then employed. They were largely reconnaisance surveys with transit and theodolite, and little was known of the value of the plane table in this order of work. In John Willington's "Elements of Civil Engineering," published in 1839 in this country, he states, in regard to the plane table: "This instrument is also very convenient for small surveys, as by its means the survey and plan are obtained in one operation, and being easily used, the Engineer and Land Surveyor frequently avail themselves of this method." It was merely a rectangular flat board, or rather panel drawing board, of at least 12 by 15 in., the frame of which not only served to retain the sheet of paper to be drawn upon, but it was graduated on its upper surface into angular degrees radiating from the center of the board. It was supported upon an ordinary tripod or stand, about 4 ft. above ground. A wooden magnetic compass box sliding into a dovetail groove was fitted on one side of the table so as not to impede the free motion of the flat brass ruler of the alidade. The alidade had vertical sight plates at each end, which were pieces with apertures like those of the Surveyor's Cross.

Small wonder that with this rude instrument, without telescope, stadia wires, or other necessary atachments or conveniences, plane table work was not in general favor, although even then the simplicity and directness of the plane table method was recognized.

It was not until the beginning of the Civil War that its economic and practical value was made available. Throughout the war it was used extensively by the War Department, and the testimony of the officers is universal in praise of its efficiency on this class of work.

The triangulation was carried on with the plane table on reconnaisance work, and the interior topography plotted in progress.

At Chattanooga accurate work was done by plane table topography and a scale of $\frac{1}{10000}$ adopted, the sheets covering about 20 sq. miles each.

Thus it is seen that the instrument is also specially adapted to a quick reconnaisance survey for military or other purposes.

In the papers of the United States Coast Survey the mode of procedure is described as follows:

"When the Army was stationary or moving leisurely, one main road was run with the plane table, the operation being accompanied by assistants well practiced in the use of the compass. Upon arriving at any important road or water course, an assistant was sent to the right and left, starting from a plane table point determined by the chaining, and running as far as was requisite; and then returning to the main road again to repeat the operation, the compass notes of course being kept in a book prepared for the purpose. Prominent points determined by the plane table were used as checks in the compass work. The intervening topography, where no compass or plane table work had been done, was sketched in by the Chief of the Party, in which accurate pacing became of great service.

"As regards office work, the instructions are explicit, as follows: All the drawing of the topographical features of a survey upon the chart should be pencilled in the field, while they are still under the eye. Sketching and plotting in the office from notes, unless the country be near at hand for ready reference in case of doubt or a defective sketch, is objectionable. Where this is unavoidable the sketch should be transferred to the sheet as soon as possible after being taken, while it is fresh in the mind of the person by whom it is made and by whom also, if possible, it should be plotted. Office work should not be commenced until the topography is entirely completed, as no inked or partially inked chart should ever be used in the field on the table."

In these instructions are shown the prime requisites in the conduct of the field work. Nothing is left to the imagination, and a truthful representation of the country is worked up under the eye of the observer being immediately plotted by him in the progress of the work. The plane table sheet will thus have a natural and artistic appearance, and all its details be truthfully shown.

In the report of the proceedings of the Topographical Conference held at Washington, D. C., January 18th to March 7th, 1892, the following principal conclusions in regard to plane table work were formulated:

1st. That the plane table is unequalled in its usefulness in every order of work, and names other instruments which would be valuable as auxiliaries. (In our work the Y level is the auxiliary instrument used.)

2d. Recommends certain improvements to the plane table, and advises the appointment of a committee to superintend the same. These improvements, of course, were those directly applicable to the small scale topographical work of the United States Coast and Geodetic Survey.

The reports of the different committees on the subjects allotted to them were very complete, and included the classification of topography, merits and defects of topographical instruments, classification of topographical field work, and the methods of the United States Government and foreign government surveys. These committees were made up of the different assistants in Government work. Their reports were the outcome of observations made by them in progress of the topographical work under their immediate supervision, and are conclusions based upon the tangible results which they were able to obtain.

There were also letters from assistants in answer to circular letters sent them concerning the most economical methods of work, and methods of securing the most work with the greatest accuracy and with the least expenditure of time and money. All were universal in their praise of the plane table method of mapping topography. Among those sent was inclosed a letter dated February 23d, 1885, from J. C. Olmsted, of Olmsted Bros., Landscape Architects, Brook-

line, Mass., relating to the cost and requirements of topographical work of a special class, which especially interests us. He states:

"The prices of topographical surveys made under our direction have ranged from $2.50 to $20.00 or more an acre. A well-educated surveyor, handling the instrument himself, and plotting and drawing himself, with two apprenticed or cheap-waged assistants, can map open or nearly open ground sufficiently accurate for preliminary estimate of earth work and general plan of roads, etc., for an average of, say, $5.00 per acre. The best system is by plane table sheets for topography."

This is the verdict of this well-known firm, whose work as landscape architects has been very extensive in the development of public grounds in many of the large cities throughout the United States.

In the report of Assistant R. M. Bache, of the United States Coast and Geodetic Survey, he says:

"I deem the modernized plane table the best topographical instrument extant; I say more, that it is the best topographical instrument possible, for the simple reason that it combines the office with the field; that whereas the field transit entails the maximum of elaborate notes and the maximum of precise sketching, and not only renders it possible and certain that discrepancies will manifest themselves eventually in plotting, even when the greatest care has been taken in the field, and also that to obtain final results there must be a great expenditure of time, its final product for elaborate surveys (and we are supposed to be speaking only of those at present) is, as compared with that of the plane table, at best bald and skeleton-like, unless play be given to the imagination, which should have no part in topographical delineation, save in the acceptance and artistic treatment of conventional signs.

"In its capacity, through easy angling upon or telemetering to subsidiary objects, to determine them, nothing can be conceived as affording greater facilities for all horizontal work."

In Queens Borough, where the plane table work has been in progress for the last three years, the regular stock instrument as made by the Keuffel & Esser Co., of New York for the United States Coast and Geodetic Survey is used. This being of light pattern was selected as suitable to the nature of the ground to be represented. As much of the Borough consists of easy, undulating ground allowing of a rectangular street layout, the principal object of the plane

table work is the determination of the limits of the drainage areas in figuring the sewerage systems, and in the general location of the several rectangular street systems. Continuous map rolls, running between the co-ordinate lines, which extend across the Borough, are carried on the rollers of the table. The direction and length of these sheets in the co-ordinate lines varies according to the judgment of the country to be surveyed. An average of 8 acres per day in open country, and 5 acres per day in wooded or rougher country, is the general record of a field party of four men. These field sheets are of unprepared blue-print cloth, which has been found serviceable in this respect.

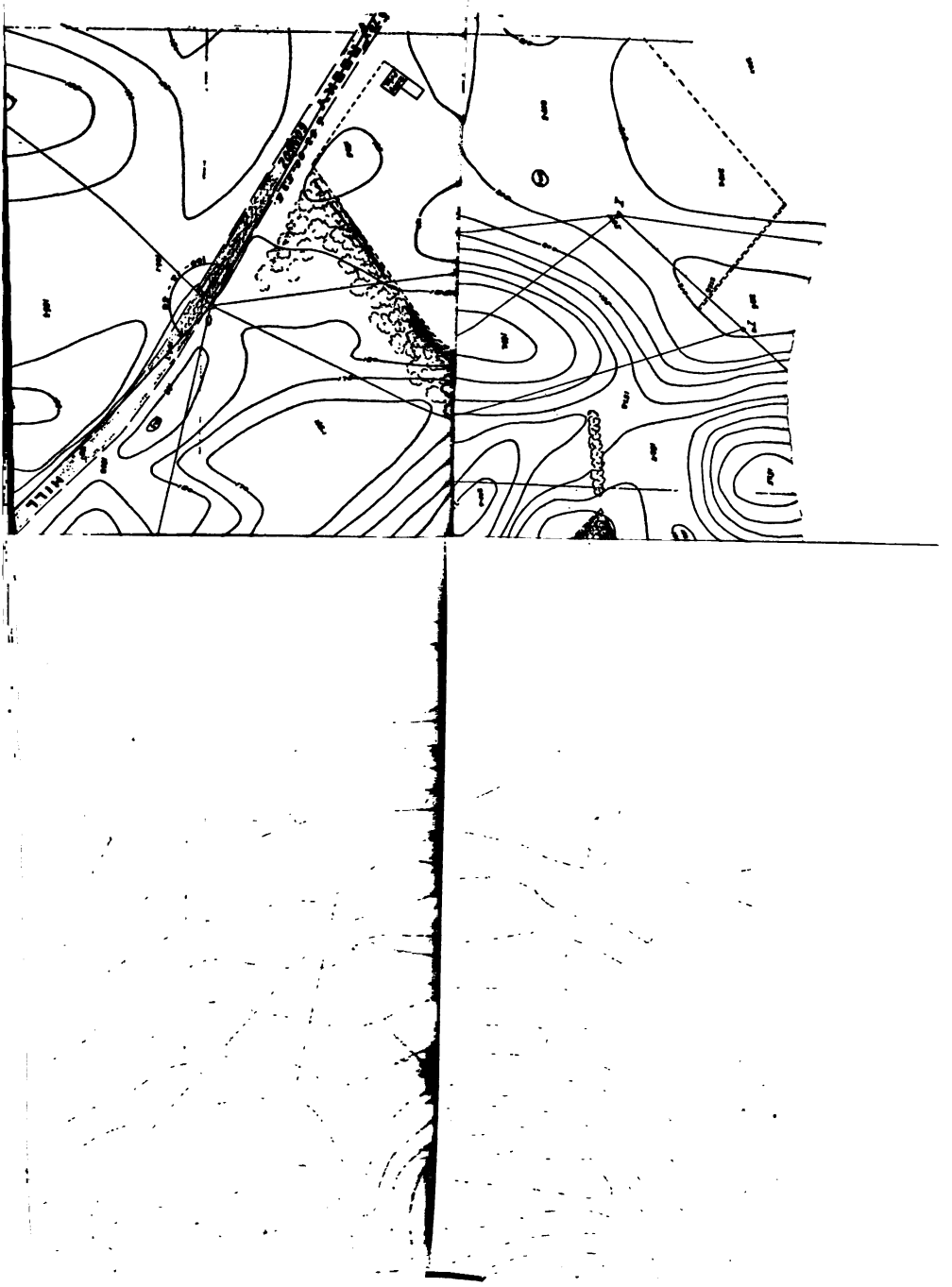
Eighty ft. to the in. is the scale used here (Plate LIX). The work on these long sheets is afterward transferred in the office to the final topographical sheets and a reduction made directly from the field map by Pantograph for study for proposed street layout and grades. The contour is determined by Y level and plotted in progress on the table by stadia readings to each point as obtained. All locations are plotted on the sheet by stadia readings.

And now we come to the plane table in its most perfect form, specially adapted for topographical work in Richmond Borough. This borough, not to be outdone by the enterprise shown in Queens Borough in the adoption of this superior method of mapping topography, has brought the plane table method to its highest state of efficiency.

Under the direction of Mr. George W. Tuttle, Principal Assistant now in charge of the Topographical Bureau in the Borough of Richmond, the plans and specifications were drawn up for a special table as best suited to the requirements of the topographical survey in this borough. The instrument as made by the Keuffel & Esser Co. has amply filled these requirements. It is the result of much careful experiment and study, additional improvements and attachments being made as their need was determined in actual practice. This model and the several attachments thereof, can be said to be the best instrument for this class of large scale municipal work yet produced (Plate LX).

The principal features are, first, the large tripod head, which affords a solid bearing for the table, thereby maintaining its level for all positions of the alidade on its surface, and an adjustable

PLATE LIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAW ON HISTORY OF THE
PLANE TABLE.



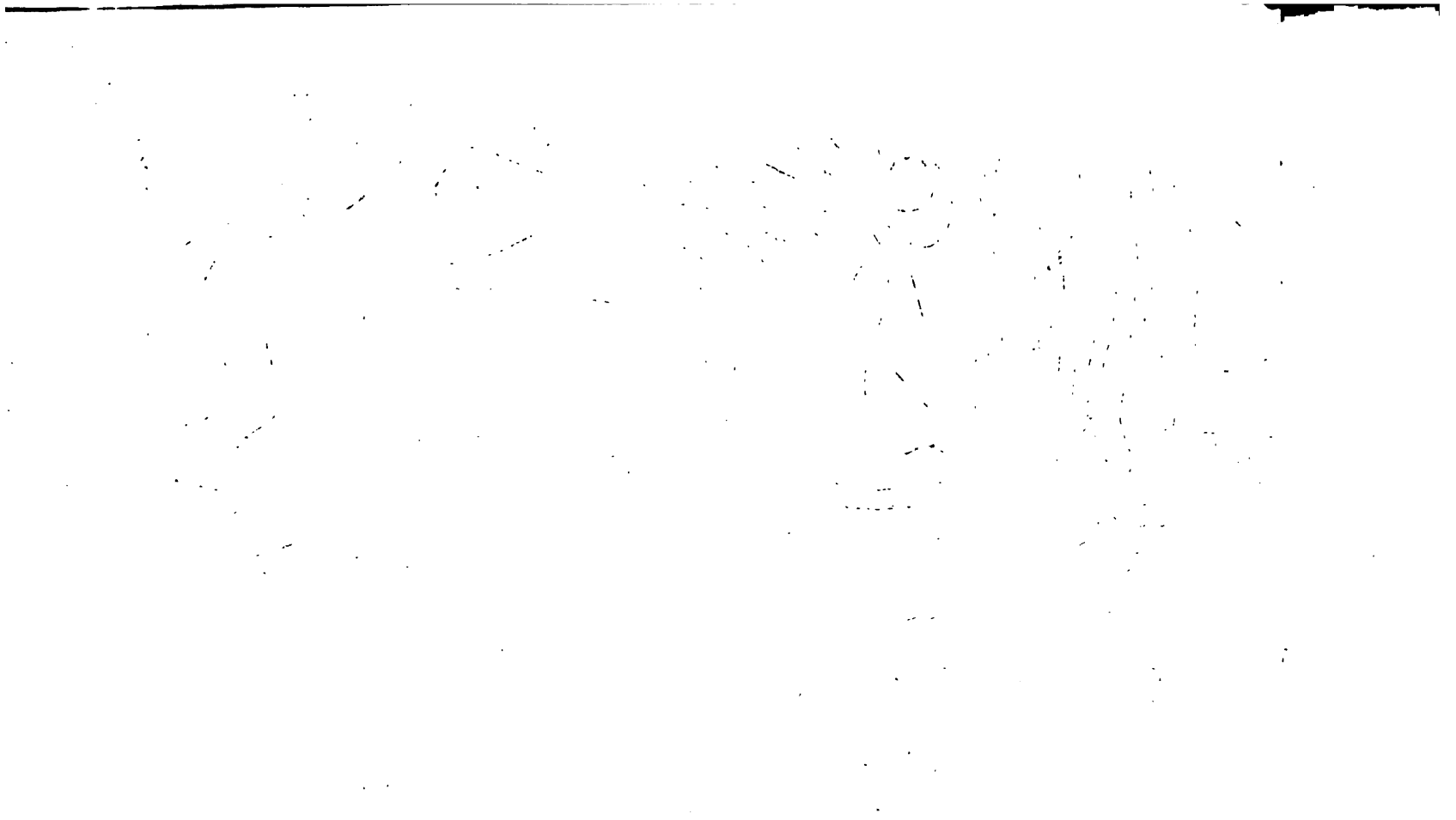


PLATE LX.
THE MUNICIPAL ENGINEERS
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LAW ON HISTORY OF THE
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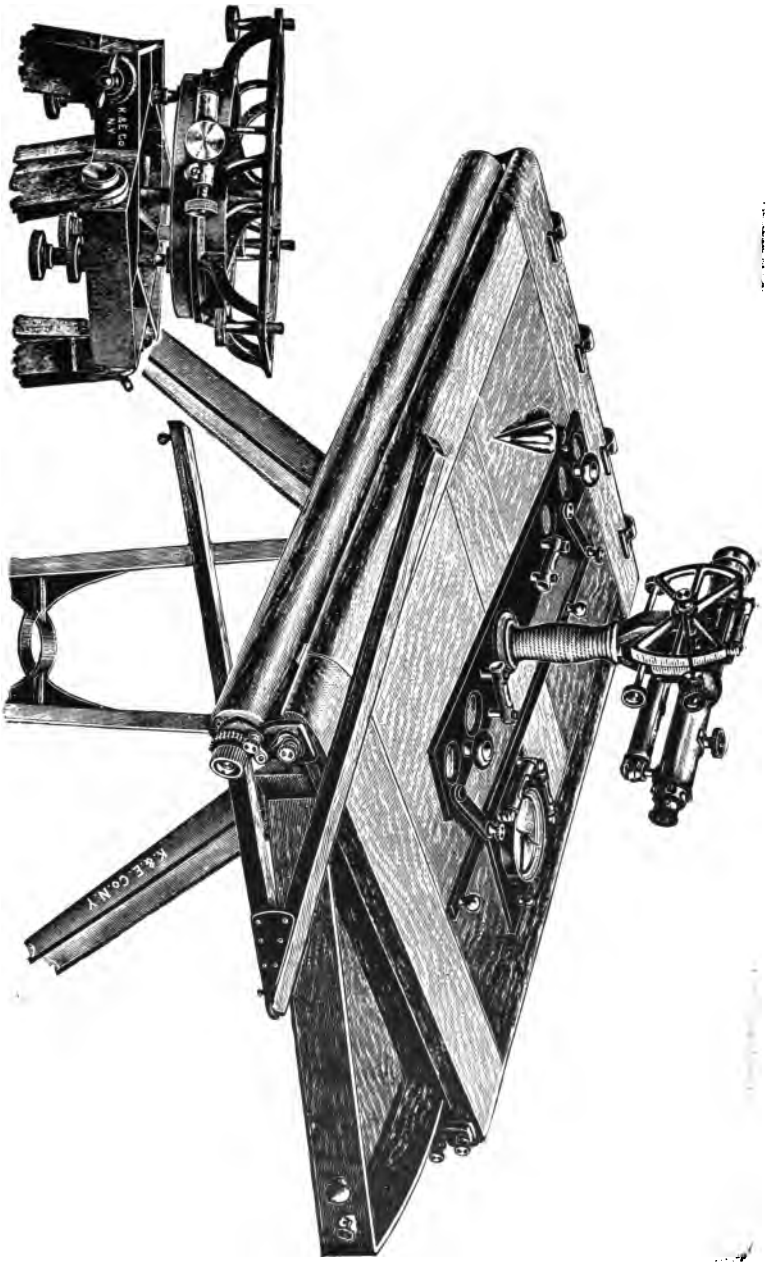
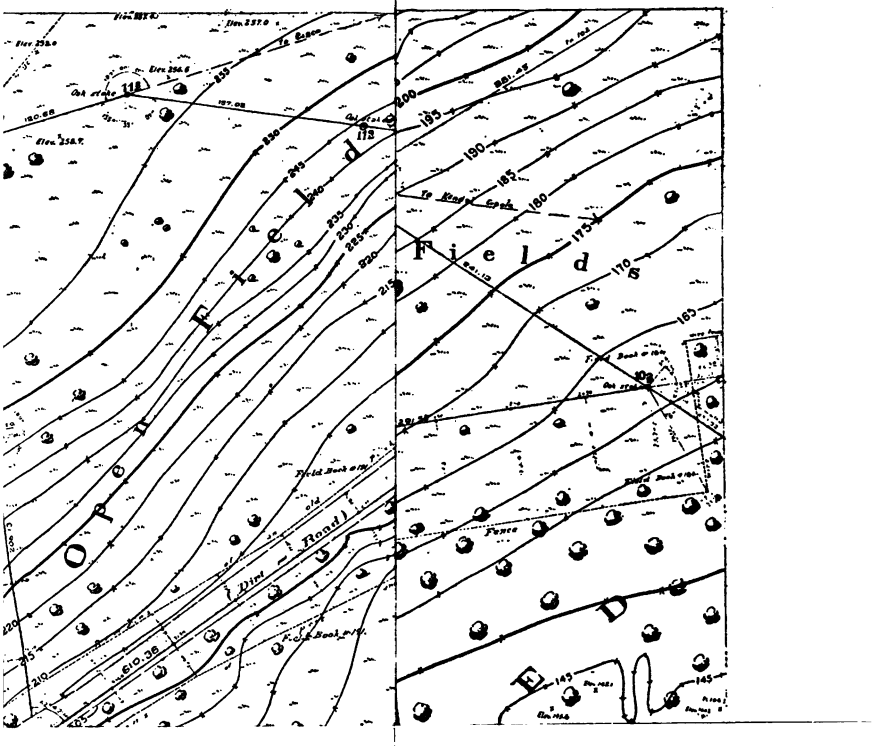
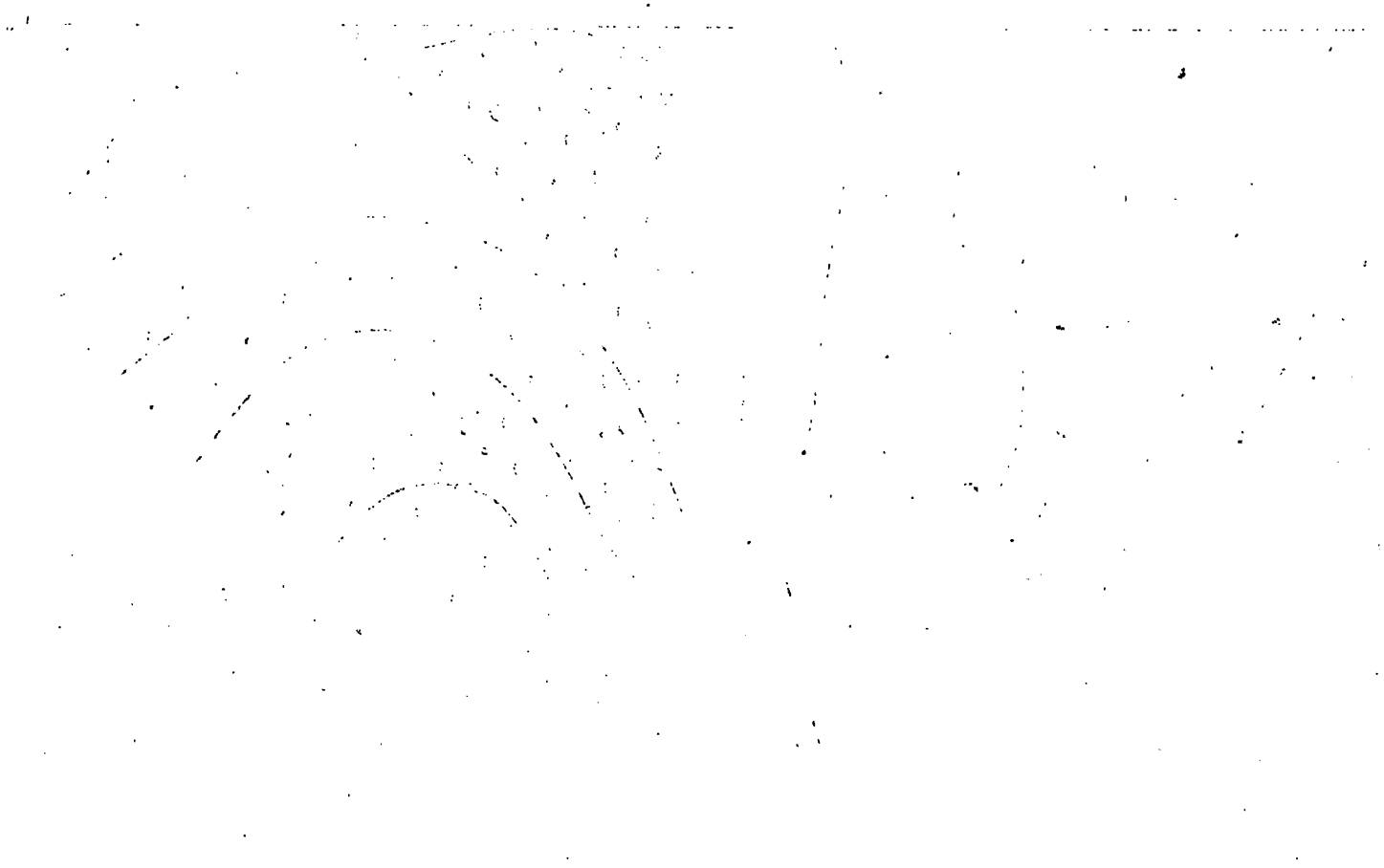


MODERN PLANE TABLE.

PLATE LXI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAW ON HISTORY OF THE
PLANE TABLE.





bubble on the vernier admitting the leveling of the vernier independent of the table level, and by means of which vertical angles are obtained to the nearest minute. This has proved invaluable where vertical angles have been measured, obtaining points in elevation on the sheet where the contour could not be readily run in on the ground.

The table was specially designed for carrying, with ample margin, the mounted Whatman sheets which are carried on the large rollers on the sides, and on which the field work is directly plotted. The rollers are detachable and adjustable, to maintain their parallelism, thus keeping the sheet evenly stretched. An improved method of attaching the sheet to the rollers admits of its being readily detached and quickly replaced by another when needed.

Other conveniences in the handling of the screws and other attachments greatly facilitate the work. A swing drawer under one side, for holding draughting materials, completes the outfit.

The conditions as presented in Richmond Borough of extremely hilly country, necessitating an accurate determination of the street system and grades, calls for a closer delineation of the ground surface. The scale, 50 ft. to the in., as adopted here, is best suited for a careful and accurate determination of the contours as located by stadia, as the scale used holds the accuracy of the stadia readings in connection with the plane table work.

As to the operation of the plane table in this field, it consists of traversing ahead of the plane table and transit location of all property lines and buildings (Plate LXI). The co-ordinates of the stations thus run and closed are plotted on the sheet, as are the transit locations. The plane table is then set up on these stations in succession, oriented into position, and its position checked by pointings at other stations, which are plotted in advance on the sheet. Bench runs with spirit level, closing on the primary bench mark, are run throughout the framework of controlling traverse, the elevations of the several stations are determined, and convenient bench marks established for the use of the Y level in conjunction with the plane table.

The plane table in position, the mode of procedure is as follows:

The height of instrument of the Y level having been checked within the circuit of the bench marks run, the rodman sets his target

to a reading which, when in the horizontal plane of the Y level, will place the foot of his rod on the even 5-ft. contour. He then travels along the contour as directed by the leveler, locating every appreciable change in its direction, the determining points being recorded on the plane table sheet by stadia readings to his rod as fast as obtained, until he reaches the limit of operation in that particular locality, which averages 500 or 600 ft. from the table (Plate LXII). The point I wish to emphasize is that absolute freedom from error is obtained in the plane table method of mapping topography.

The principal advantages of the plane table method are:

(1st.) The plotting of the work in progress, by which

(2d.) The proof positive of the work as obtained reduces the chance of error to a minimum, as

(3d.) The immediate plotting of the contour or location on the sheet is made possible, thus furnishing an additional means of proving each step in filling in the topography, and cultural details. This filling in of the topographical features is made in progress of obtaining the relief of the terrene.

The location of buildings and fences, roadways and ditches, streams, marshes, ponds, wooded and cultivated land, proceeds without delay as fast as readings are taken from the table.

The principal attribute of the civil engineer is accuracy, and he demands that every move shall be immediately proved as soon as made; thus in transit work we have the addition of angles measured in combination at a station, the closing of the horizon, the summation of interior angles in a polygon before leaving the field of operation, and the closure by bearings and distances of the plot. The plotting of the topography based on this adjusted triangulation and traverse system demands the same proof, before being permanently recorded on the final sheet, and this the plane table method admirably provides. The plane table sheet is the open field book, upon which the progress of the field work is plotted. The process of plotting the configuration of the terrene as viewed by the topographer is best compared with that of the artist, who sketches from life in perspective, the features of the landscape in their true position. He does not rely upon notes which are afterward transferred to his can-

PLATE LXII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAW ON HISTORY OF THE
PLANE TABLE.

PLANE TABLE PARTY.

In Richmond Borough the Plane Table Party consists generally of four Men—Topographer, Leveler, and two Rodmen.

vas by himself or an assistant in the seclusion of his studio; but the picture is drawn under the eye of the artist. In like manner the topographer draws in plan and to scale the topographical features as fast as determined on the ground, and at the close of the day views with satisfaction the record of his work, well done and accurately mapped.

DISCUSSION.

CARL M. BERNEGAU, Esq.—I want to add a few remarks about the plane table as it is used by the Army Engineers, which must be portable and is really a sketching board. It is a small instrument, about 6 to 8 in. square, and is held by a strap around the arm. It has a graduated scale which swings from the upper edge and this scale at the same time is used as a clinometer. The upper edge carries also a compass.

The instrument is very complete and enables the military engineer to do his work on horseback. Different colored pencils serve as the conventional signs which have been adopted by the engineers for roads, etc. I have been told that by means of this instrument the engineer obtains as good a map for his reconnoissance as is otherwise possible only with far more elaborate instruments.

ROBERT R. CROWELL, Member of the Society.—I myself have not had a great amount of practical experience with the plane table itself, but I certainly see the importance of it, and, also, its importance for the work in hand in Queens Borough; and I think that if the plane table had been used throughout the City for this class of work, the City would be quite a number of dollars better off than it is at the present time. I think that it is one of the most economical machines that has been invented for this purpose.

GEORGE W. TUTTLE, Member of the Society.—There is one point I might call attention to, and that is the educational value of the plane table. It is a great help to young surveyors by enabling them to compare the topography before them with the map they are making, and its practice teaches them in all kinds of surveying to represent their work accurately and omit no essential details. Its practice should be taught in the field, it seems to me, in every course in surveying. I have observed that its use aids greatly in interesting all members of the field parties, particularly those who are anxious to learn the art of surveying by picturing before them the work they have done and are doing. I am heartily in favor of the use of the plane table for filling in topographical features and I share Mr. Law's high opinion of its use for that purpose.

THE AUTHOR.—That is the principal feature of plane table work, that we are able to detect at once any error in plotting the location. The work being plotted in its progress, errors are at once found. It does not go upon the record to be found later, in the course of some months, when a great loss of time and money is involved in looking up old transit stations and old records, in order to rectify these errors. The transit will always be a universal instrument on triangulation and accurate traverse surveys, but for filling in topography the plane table is the paramount instrument.

SAMUEL C. THOMPSON, President of the Society.—I would say, gentlemen, in this case, it recalls to my mind the experience of a friend of mine during the Civil War. He was a surveyor before going into the army and was engaged in the artillery. While he was before Petersburg, he took it into his head that he would like to know about how far the Confederate lines were and just how their fortifications were arranged, for purposes which you can readily imagine. With the intention of obtaining this information, he took a cracker box—instruments were scarce at that time—went out in front of the line, turned the box over and sat down, observed, of course, from the Confederate line. He worked from one point, took his different directions to various objects, different portions of the other fortification, and then carefully paced the distance. He had had quite an extensive experience in pacing and could do it very accurately. He crossed to another point which he had sighted, put his box down there and took his intersections. By that time the Confederates began to think he was doing something he had no business to do, so they opened fire on him and he left. He did not finish the survey completely, but he got enough of it to locate quite accurately the Confederate works, with the result of being able to gauge the gun a good deal closer next time.

MYRON H. LEWIS, Member of the Society.—In doing a great deal of topographical work up on the Croton Dam, the Y level and transit were used and the old method of cross-sectioning or laying out the ground in 100-ft. squares was followed. In that country the plane table would have been the ideal method. I think under the most favorable conditions up there, we could fill in about 10 to 12 acres of topography a week with a party of six men and everything in our favor. The section of the country to be mapped had all been previously traversed, co-ordinates computed and plotted and yet we had to get the contours by means of a chain and Y level. The method was slower, more tedious and inaccurate than the plane table. If we did 20 acres per week we did mighty quick work. In Queens, with the plane table, we have been doing as much as 100 acres a week under favorable conditions. Mr. Law said 3 to 8 acres per day, but he had difficult country to work in. I know our own party has mapped as much as 90 acres per week and I think some of the other parties have done a hundred acres and better.

I wish to ask Mr. Law about the degree of accuracy of the plane table, what he thinks is the degree of accuracy of the single observations and what he considers the degree of accuracy of plane table traverse.

THE AUTHOR.—That is a very good question. The plane table holds an accuracy of .2 in 100 on the large scale of 50 ft. to the inch.

On this scale it holds the accuracy of the stadia work in plotting it, and this a smaller scale will not do; therefore that accuracy is thrown away, that is, to some extent. Of course, in the borough of Richmond, we have to avail ourselves of the closest method of plotting the work; the nature of the country demands it. But we can secure the required accuracy on the plane table work. The stadia readings, as taken from the table, will hold the foot in 500. The distortion and shrinkage of the sheet are not apparent, because the sheets are properly seasoned before being sent in the field. The distortion and shrinkage are no greater, if as great, as that of a sheet kept in the office and subjected to different temperatures, extreme heat and extreme cold, when near or away from the fire. The accuracy in plotting is .2 in 100; we can hold that.

MR. CROWELL.—I do not think it is necessary to go to a very great degree of accuracy in 5-ft. contours, because we have four other contours that we have to interpolate. That is why I think probably a smaller scale would be just as well as a 50. I think perhaps a 100 or 200 ft. would give the same result as a 50-ft. If we were running 2-ft. contours then it might be different, but as you have 5 ft., I think probably 100 or 200 ft. will do just as well.

THE AUTHOR.—The value of the large scale does not enter so much in the location of the contour as it does in the plotting of other locations, and in checking the stations in the traverse, the coordinates of which are plotted in advance on the sheet. It is also a further check on the location of the transit lines previously plotted on the sheet. It enables us to check such locations to the nearest foot, besides checking the locations of the contours. You see, the nature of the ground in Richmond Borough is frequently hilly and the contours are brought so closely together that this scale is used in order to better distinguish them and to obtain a closer determination of the street system holding good grades. Therefore it is necessary in establishing them to hold this location as close as possible, and this we have been able to do. There is nothing lost in using a large scale; we make just as quick progress. There is not so much accumulates on a sheet of regular size and the effect of distortion or shrinkage, if there is any on the sheet, is proportionally less. That is quite an important factor.

HERMAN K. ENDEMANN, Member of the Society.—I think that the superiority of the plane table, as demonstrated in Queens Borough, is especially apparent in the location of contours, not so much in the location of buildings and fences. It is very evident that were a contour to be located by any other means, say by transit survey and Y level, and sent to the office to be plotted, if the country is at all rough and the contour lines irregular, it

is almost impossible to put down at the office the contour as it is in the field.

In the field a great deal of time is saved because it is necessary by this method to locate only one-fourth or one-fifth the usual number of points in order to get an accurate contour, for the simple reason that the man in charge of the party can go up and sketch in a contour between two points located and any little departure from a straight line he can readily judge by his eye. Of course, how far it is safe to do this has to be trusted to the judgment of the man in charge of the work. If accurate work is desired, it is not well to take too few points, that is very evident.

EDWIN H. THOMES, Member of the Society.—I would like to know the author's opinion in regard to the difference of following the contour with a Y level and of getting the contours by using the vertical angle and stadia for hillside work. You take a vertical angle and stadia and reduce that to elevation and a horizontal distance. They do not use any vertical angles at all in Queens, but simply follow each contour by the Y level. On this plane table you have the attachment for reading a vertical angle, and I understand they have the diagram method of reducing those readings to horizontal distances and elevations, and I would like to know the details where you would use one method and where you would use the other and the advantages of each method.

THE AUTHOR.—We use a vertical angle only where we can save time in determining the bottom, or summit elevations in thick country, and elevations on steep slopes where such cannot be quickly obtained with the Y level. These can be speedily obtained by the plane table by means of the independent bubble on the vernier of the vertical circle and by taking off the horizontal and vertical components from the stadia diagram in the field. The elevations are then immediately plotted on the sheet. Though, as I have said before, as a rule, we follow out the contour on the ground, securing by this method a constant check on the work in progress.

HENRY I. LURYE, Member of the Society.—Although I must confess to not having used any plane table at all, still I am afraid we are too hasty in forgetting our old friend, the transit. After all, I think a plane table is purely and simply an instrument to determine contours, nothing more. As a rule, in city surveying, which has to be highly accurate, the work cannot be so well done as with the transit, of course, barring contours; and then, after all, it seems to me, from what I have heard, that the contours are not determined so much by the table as by the level, the distances only being determined by the table.

THE AUTHOR.—What I have stated in the text of my paper amply answers that argument, namely, that the plane table is based

upon the transit work, transit lines as previously run, closed and the co-ordinates of the stations determined. The fillings in of the topography and plotting of the cultural details is best done, for the reasons I have demonstrated, with the plane table. We are not working in Wall Street and the thickly settled part of the city; we are working out in open topography and representing all its topographical features, such as property lines and buildings, winding roads, lakes and marshes, and for this the plane table method is the best. Where accurate location is not required of the transit, the plane table is the only instrument for safely filling in those details. A true representation of the country is thus obtained.

ERNEST ANKENER, Member of the Society.—I also would like to break a lance in favor of the plane table, the operations of which, when sustained by a system of co-ordinates, based on a triangulation or other system of traverses, will produce results which are amply sufficient for the graphical construction of tentative plans or maps of the territories to be covered by a new layout of streets, etc.

The plane table should always be accompanied by a theodolite, to be used for the determination of the consecutive positions of the plane table (by traversing) of which the co-ordinates are to be determined in the field, thus orienting the table constantly by such traverse lines or means of marginal marks to any visible co-ordinated triangulation stations, etc. This theodolite's telescope should have leveling attachments and vertical circle, so that contour lines may be directly determined by the same by keeping the telescope constantly level or reading "vertical" angles, the plane table's operations being only (by stadia readings) to determine the necessary number of points along such a contour, thus not overburdening the table with operations of various kinds. A single-starting point on each sheet, plotted by its co-ordinates and a marginal mark in line with a visible triangulation station, will, as before stated, assemble the operations on this sheet around such a station, and will produce faithful work and prevent almost surely any error. Two known stations on each sheet, apart as far as possible, would also be sufficient—such stations need not necessarily be intervisible.

Even without a triangulation or traversing between the stations by theodolite and steel tape, plane tabling may be carried on to quite an extent, principally when small scales are used for the sheets in the field.

I had occasion to have charge of a plane table party in Mamaroneck, Westchester County, N. Y., during the year 1870, where about 2 500 acres of land were surveyed in detail, using for the determination of the areas of the various farms therein con-

tained, transits, chains, etc. Three plane table parties were added for the detail work of topography.

I measured a base line on the New York & New Haven R. R. of about 2 500 ft. in length, and by graphical triangulation, so to speak, covered the various sheets with stations from which the detail work was done; these stations I determined as the work progressed, and often graphical proofs in the field were available when stations or elevated points previously determined became re-visible and could thus be re-established or checked with very satisfactory results.

These plane table sheets were constructed in the field at 200 ft. to the inch, and stadia readings were taken up to 600 ft. which was allowable, due to the smallness of the scale. An error in the location of a small river plotted on the plane table sheets was immediately discovered and corrected.

The Long Island City topographical survey was commenced in 1871 under a commission authorized by an act of Legislature. It was done similar to the surveys of Morrisania and other adjacent territories in the 23rd and 24th Wards of the City of New York (Annexed Districts) by actually running out a network of squares over the entire territory and starting and closing all traverses from such lines and to such lines (the squares were fixed by locust posts every 1 000 feet). The origin of the system of co-ordinates was placed near to the centre of city, choosing the intersection of the centre lines of Rapelye and Pierce avenues, as such. The right angles of these squares were set out by theodolites with two telescopes at right angles to each other and a mean from 8 points obtained, 4 from both telescopes, each up and down and then 4 points with quadrant changed. These squares covered the area between Newtown Creek and Bowery Bay and between the East River and the boundary between Long Island City and the old town of Newtown from about 8 000 south to 12 000 north and about 5 000 west to 5 000 east.

Within these squares, by traverses as before mentioned, the entire survey was performed, showing all distances and angles of the traverses, thus locating all roads, water courses, property lines, buildings, high and low water lines of the East River and Bowery Bay, within these squares. For purposes of contour work, smaller squares of 100 ft. sides were run out and the elevation of each corner of the smaller squares were taken and intermediate when sudden charges of the ground so demanded it.

A number of maps (about 50) drawn at the scale of 80 ft. to the inch, were thus obtained, each extending northward and southward 2 000 ft., and eastward and westward 3 000 ft. From these maps one single large map, "The Survey Commissioner's Map of

Long Island City," was plotted, showing at the smaller scale of 250 ft. to the inch or 1/3000, the various villages with their different old street systems as found in possession and the new street system of the present Long Island City, with its parks, squares, etc., giving the width of all streets and avenues and the size of all regular blocks, but no angles or dimensions of any block with angles other than right angles. After this map was filed, the monumenting of the new Long Island City Street System was commenced and finished entirely independently of the elaborate system of squares run out and its traverses before mentioned, following only the intended delineations of the large tentative map.

Only with the filing of the "final" monument, grade, etc., map the official City Plan could be called complete.

The plane table method as now applied in Queens Borough is entirely sufficient for the production of maps of the Official Street Systems, which also includes the establishing of grades, and which maps, when adopted, must be followed by the actual monumenting of streets, thereby determining the block angles and dimensions.

MR. LURYE.—Is the accuracy of the plane table sufficient to enable a topographical engineer to lay down the streets properly and economically?

THE AUTHOR.—Yes, it is. It is used for that purpose. The sheet that we turn out on the plane table with the topographical details filled in is sufficient for all studies of street lay-outs and grades in this class of work.

CAMILLE MAZEAU, Member of the Society.—Mr. Law has very clearly shown us the place that the plane table can occupy in topography. However, I would like to ask him if the plane table is sufficiently accurate to establish the street system, or will it be necessary to re-run the traverses and make transit locations for the damage map?

THE AUTHOR.—The traverses plotted on the sheet are all transit traverses, and on each closed transit traverse the plane table work is based. There may be a short spur run out; one or two are allowable within or without the closed traverse, but that is all allowed by us for contour or location work.

All of this work serves mainly as a study to establish the general street system, and as a general topographical survey it must not be confused with damage work. The traverses are permanent, the filling in of the topographical details being done by the plane table.

MR. CROWELL.—I would like to ask about what is the length of your traverse line; not more than 500 ft., is it?

THE AUTHOR.—The average is 500 ft. That is the limit of our work from the table.

MR. ENDEMANN.—How many men does it take to run a party in Richmond? How many to run one in Queens? And what kind of

men are necessary for the work? Need all be experienced men or can inexperienced men and men with no technical training be used to advantage?

THE AUTHOR.—A plane table party is made up of four—the plane tabler, the leveler and two rodmen. That, at least, should be the make-up of the plane table party. It has been found that axemen have been able to do very good work in this connection and it is absolutely necessary that the rodman know his business. He has an excellent opportunity to display his talent in running a rod, for he has to have a pretty fair knowledge of the progress of the work. But we have no trouble in this respect and the work is simple and direct. Any experienced transitman can very quickly take up the plane table and operate it and understand its geometrical principles.

MORTON L. FOUQUET, Member of the Society.—I do not agree with Mr. Law regarding the make-up of a plane table party. From our experience in Queens five men distributed as follows will give the best results as regards accuracy and area covered: a topographer at the table, a man at the level and two rodmen and the engineer in charge of the party. The engineer in charge of party by occupying, from time to time, good vantage points, can easily direct the movements of his rodmen and, at the same time, keep the man at the table posted as to the lay of the land, which enables him to plot the observations he takes intelligently. Such a party make-up, it seems to me, is far superior to one using but four men. With but four men, the head of the party usually runs the table, which he is forced to leave at frequent intervals to study the ground and direct the work. This is a great waste of time, particularly when he is taking observations 500 or 600 ft. away.

MR. LEWIS.—I fully agree with Mr. Fouquet. I have always found it necessary to be at the heels of the rodmen. Very often we have green men and if the man at the head of the party is not with them a great deal of the time, the contours will not appear on the map as they are on the ground. Unless you have men that have been broken in and thoroughly understand the work, the results will not be satisfactory.

We have been able to run three rods. Of course there is more work on the man at the table, but where the ground is open it has saved us a great deal of time to have three rodmen—one man at the table and one man to direct the rodmen. As Mr. Fouquet said, it is not possible to do accurate work without observing whether the rodmen do not skip over the hills and hollows. We cannot see the lay of the ground 500 ft. from the table and the man at the level cannot see it 400 or 500 ft. from his instrument, so that it has always been necessary to have at least five men to do good work, and we have been able to run with six men very advantageously.

JOHN T. METCALF, ESQ.—I think the difference in the topographical conditions in the two boroughs is responsible for the difference in the opinions of the two men. In the borough of Queens they can see probably from 500 ft. to 1 000 ft. away from the table, while in Richmond it is seldom possible for us to see more than 300 ft. on account of the configuration of the country and thick growth. So, in Richmond, it is possible for the man at the table to direct the work.

THE AUTHOR.—In Queens contours were run out considerably over 500 ft. from the table. They ran out 800 to 1 000 ft. and even further, 1 500 ft., and therefore it was quite a distance between the determining points in the contour and I have kept three rodmen moving in that territory as fast as they were placed by the leveler. They were always in position and proved serviceable men to me. In the Coast and Geodetic work the plane tabler is always at his table, as a rule. Of course, that work does not apply to our scale of work. Our methods are not applicable to the smaller scale on which they work, as 1/10 000, whereas, in Queens, we work on a scale of 1 in 900, and in Richmond we work 1 in 600.

MR. LURYE.—Is there any person present who has had any experience with a photographic survey, and, if there is, can he tell us anything about the subject? How does it compare with the plane table?

THE AUTHOR.—It does not apply here. In European and American surveys the photographic work is being introduced now on the smaller scale work, 1/100 000, 1/200 000, 1/500 000 for military and reconnaissance work, but it has nothing in common with plane table work, so far as I can see.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

REPORT OF THE SPECIAL COMMITTEE ON ASPHALTS.

COMMITTEE: GEORGE W. TILLSON, OSCAR W. VON DER BOSCH, CLARENCE D. POLLOCK.

NEW YORK CITY, March 22d, 1906.

DIRECTORS OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

GENTLEMEN:

Your Special Committee appointed for the purpose of ascertaining the costs and methods of repairing asphalt pavements herewith submits the following report:

The accompanying blank (see next page) was sent to twenty of the leading cities in the country which have the largest amount of asphalt pavements, with the request that it be filled out in detail. The object was not only to ascertain the actual cost and method of repairing asphalt pavements, but if possible to determine the cost of repairs according to the age of the pavements. Only eight of the cities replying have kept their records in such shape that this could be obtained and the results are embodied in the accompanying table. The figures are all for the year 1905 except Washington, which is for the year ending June 30th, 1905. Although not being able to furnish just what was desired, the following cities gave information regarding their methods:

In Philadelphia there are about 25 miles of asphalt out of guarantee and it is stated they all require resurfacing entire. The

prices for resurfacing in patches of 100 sq. yds. or less for 1906 are $1.19 per square yard, patches between 100 and 500 sq. yds. $1.17 per square yard, for surfaces from 500 to 1 000 sq. yds., $1.11 per square yard, for over 1 000 square yards $1.07 per square yard. It is said the amount expended per year depended upon the annual appropriation rather than the need of the streets.

COST OF REPAIRING ASPHALT PAVEMENTS

IN THE CITY OF.....FOR THE YEAR 1905.

Age of Pavement.	Sq. Yds.	Cost per Sq. Yd.
Six Years		
Seven Years		
Eight "		
Nine "		
Ten "		
Eleven "		
Twelve "		
Thirteen Years		
Fourteen "		
Fifteen "		
Sixteen "		
Seventeen "		
Eighteen "		
Nineteen "		
Twenty "		

METHOD OF PAYING.

Per cubic foot of material used { top ..... / binder .....
Per square yard of pavement actually laid .....
Per square yard of entire area .....
Give unit price by whichever method.
Length of guarantee period .....

In Minneapolis the area repaired last year was wholly in streets under guarantee where the contractor had failed to live up to his agreement. They were made at a cost of $1.65 per square yard. The total yardage laid under this arrangement was 4 525 sq. yd., but no statement was made as to the total area of the streets as repaired.

In Milwaukee no account is kept of the cost of repairs by years, so nothing definite could be obtained.

In Omaha the repairs are made by a municipal asphalt plant, and while no statement was made of the cost by the age of the pavements, the total of 5.8% of the entire yardage repaired was relaid. This would mean at a cost of 82 cents (.82) per square yard, an average of 4¾ cts. over the entire area.

In Kansas City the method of repairs is such that the following quotation is made from a letter of the Engineer:

"We have repaired since 1903, when the first repairing of asphalt pavements out of maintenance was begun, 41 miles of streets, amounting to 88 000 sq. yds., costing $124 277.65. The cost of this work has been $1.50 per square yard until within the last year when the Economic Asphalt Repair Company came into the field with their Surface Heater. Since then the price has been cut to 90 cents per square yard. Previous to this time all repairing work was done by the Barber Asphalt Paving Company and the method used was to cut out all worn asphalt and replace by new. This latter method was very unsatisfactory, leaving the street in a lumpy condition, and in a short while after this work was done a bad place or hole was likely to develop alongside the place repaired. It is also very difficult under this method to get a good joint. These repair contracts are for two years—they agreeing to keep the street in condition during the two years of their contract and tax bills being issued for the work done on the street at the middle and end of the period of their contract. This has resulted in the work being in a state of continual repair, tax bills being issued at the end of each year, at the end of the period of the contract the street being in a little better condition than when started."

In New York City, Borough of Manhattan, it is reported in 1904 265 000 sq. yds. were maintained at a cost of $201 167.38, or practically an average of 76 cents per square yard; in 1905, 460 882 sq. yds. at a cost of $161 800.90, or an average of 34 cents per square yard; in 1906 there will be maintained 760 091 sq. yds. at an estimated cost of $216 235.00, or 28½ cents per square yard. These figures of Manhattan seem excessive and are very much more than is paid by any other city. This is probably due to the heavy traffic of the Manhattan streets and the fact that many streets have been paved with asphalt where that material does not make an economic pavement.

The committee feels that some benefit has been derived from these investigations, but also feels that these reports show how little uniformity there is in the practice of the different cities, and that some officials do not care enough about obtaining the information to keep the proper records. It would seem a comparatively simple matter to so keep the records of asphalt repairs that a permanent good would be obtained, and by comparing the methods and costs of other cities a general benefit, not only to themselves, but to their officials, would be derived. Quite a number of the cities to whom circulars were sent did not even reply, although it was stated in the letter accompanying the blank that copy of the report would be sent to all officials replying. The committee would recommend that when the report is printed it be sent to the city engineer or official in charge of the asphalt repairs in all the cities of the country containing any material amount of asphalt pavement, with the request that permanent records be so kept that a table similar to the one accompanying this report can be made out and in that way the costs of repairs to asphalt of the different cities can be intelligently compared.

All of which is respectfully submitted,

GEO. W. TILLSON,
O. W. VON DER BOSCH,
C. D. POLLOCK.
Committee.

TABLE SHOWING THE COMPARATIVE COSTS OF REPAIRING ASPHALT PAVEMENTS IN VARIOUS CITIES DURING THE YEAR 1905.

Age of pavement.	Brooklyn.		Buffalo.		Rochester.		St. Paul.		Toronto.		Washington.	
	Sq. yds.	Cost per sq. yd.	Sq. yds.	Cost per sq. yd.	Sq. yds.	Cost per sq. yd.	Sq. yds.	Cost per sq. yd.	Sq. yds.	Cost per sq. yd.	Sq. yds.	Cost per sq. yd.
6 years	122 491	.001	.....	.....	.....	.....	5 077	.0016	.....	.....	63 520	.....
7 "	82 937	.007	7 862	.0110	.....	.....	.....	.....	.....	.....	70 184	.008
8 "	421 274	.030	139 296	.0210	.....	.....	.....	.....	.....	.....	40 150	.002
9 "	189 415	.018	86 458	.0129	27 680	.0253	11 385	.0812	.....	.....	70 498	.002
10 "	209 987	.043	241 666	.0028	17 844	.0283	77 115	.0945	10 499	.043	42 397	.....
11 "	44 056	.027	494 765	.0147	11 008	.0150	.....	.....	43 871	.110	83 892	.008
12 "	41 187	.028	438 540	.0276	57 155	.0098	.....	.....	5 456	.043	77 462	.010
13 "	36 706	.040	325 098	.0419	57 558	.0832	.....	.....	41 773	.100	81 078	.014
14 "	27 419	.060	305 449	.0618	23 548	.0550	.....	.....	20 027	.069	96 863	.008
15 "	5 278	.026	290 862	.0458	72 573	.0580	.....	.....	47 276	.044	128 986	.016
16 "	29 069	.064	216 660	.0590	54 397	.0788	2 096	.0090	32 640	.082	204 585	.023
17 "	87 442	.102	108 215	.0430	5 134	.0545	9 654	.0900	.....	.....	89 336	.089
18 "	20 504	.151	75 379	.0944	36 352	.0400	48 621	.0076	.....	.....	20 754	.049
19 "	235	.031	37 117	.1219	17 433	.0571	30 351	.0015	.....	.....	37 311	.017
20 "	3 448	.074	39 398	.0876	9 482	.0864	.....	.....	.....	.....	9 199	.042
Prices	Wearing surface = 67 cents per cu. ft. Binder = 25 cents per cu. ft.		1st 6 months = $1.23 per sq. yd. 2d 6 months = $0.74 per sq. yd.		$1.28 per sq. yd.		$1.65 per sq. yd.		$0.89 per sq. yd.		Wearing surface = 49 cents per cu. ft. Binder = 25 cents per cu. ft.	

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

ANNUAL ADDRESS

ON

THE PROGRESS OF MUNICIPAL ENGINEERING WORK IN NEW YORK CITY AND THE WORK OF THE SOCIETY.

DELIVERED JANUARY 24TH, 1906.

BY MR. SAMUEL C. THOMPSON, PRESIDENT OF THIS SOCIETY.

In complying with Section VI of the Constitution and By-Laws requiring that "the retiring President shall make an Address reviewing the progress of Municipal Engineering work in New York City, and the work of the Society," I have assumed that "in New York City" means, done under the control or supervision of the City, and not necessarily within the territorial limits, and have taken some latitude with the work to which attention is directed, if within the City limits.

Reversing the order of the direction given in the By-Laws, reference will first be made to the work of the Society.

The membership at the present time is 366, which, while not indicating a large percentage of increase for the year, represents a conservative healthy growth, and the Society is to-day in a much stronger condition professionally than before, although the financial status has not apparently improved. The reduced balance on January 1st, 1906, was due to many outstanding bills, many of which have since been paid.

The interest manifested at the meetings, the papers presented and the careful work evidenced in the preparation of the same, all go to show an abiding interest in the Society.

An interesting programme has been provided for each meeting by the Publication and Library Committee, and the second volume

of the proceedings of the Society has been gotten out in a very creditable manner, and has resulted in a somewhat greater financial return than was obtained from the previous volume, so that from a professional or financial point of view, the Society has good reason to be well pleased with the result attained by this Committee. A change which has been made in the time of appointing the Editor and Business Manager, should render the work of the Committee less arduous during the coming year.

The work of the House Commitee has resulted in promoting sociability and good fellowship, after the reading of the regular paper and discussion of the evening has occurred, and the success of the Annual Dinner was due to the hard work and careful supervision of this Committee. The place for the monthly meeting has been continued as formerly. The action of our Secretary, after other quarters had been reported upon by the House Committee, resulted in continuing for another year the lease of a portion of the apartment occupied as headquarters previously. It was very much desired that the rooms leased for the Society's use would prove to be a convenient and acceptable meeting place for the members, where appointments could be made, plans and business arrangements discussed, Municipal matters looked up and studied, or a quiet evening devoted to reading could be enjoyed.

The House Committee and the Board of Directors have been disappointed, however, that no such general use has been made of the quarters as had been anticipated, and a portion of the suite occupied last year was given up, beginning October 1st, on terms which were considered favorable to the Society. The consideration of permanent quarters in the New Engineering Building, has been kept in view, and a Past-President of the Society has been appointed as a committee of one, to give such attention to the acquiring of the requisite space as may be deemed advisable. The work of the Committee on Inspections was delayed in the begining, owing to a series of difficulties encountered by your presiding officer, in trying to make the actual existing conditions and the requirements of the Constitution work together harmoniously. Having finally succeeded in this, the Committee provided some very interesting excursions, full of matters of engineering interest.

Of the Special Committees in existence during the year, the Committee on Datum Planes completed its labor and submitted a very interesting paper to the Society, and prepared a card containing much of the information in tabulated form, which is at the present time in the hands of the printer.

The other Committees (one to report upon standard forms for data regarding asphalt pavements, and another to consider and report upon a uniform system of sewer design in the different Boroughs of the City) while not ready to report, have indicated their progress on the subjects assigned, and will probably make their reports in the near future.

The engineering progress in Municipal work during the past year has been rapid and in widely divergent lines, and in reviewing the same it is difficult to present it intelligently, except by calling special attention to certain lines of the City's activities.

The Topographical work in the different Boroughs has been carried forward as rapidly as proper attention to the degree of accuracy deemed necessary would permit. In one of the Boroughs it has become painfully apparent that the growth of the section has been and is being materially retarded by the lack of completed, proper and systematic surveys, which being the basis for all public improvements, must be completed in a more or less careful manner before definite street lines and grades can be laid down, or sewerage systems developed. An intricate problem which has confronted the engineers in the Borough of Queens is the elimination of the numerous grade crossings of the Long Island Railroad.

The loss of life since the electric installation on the Atlantic Avenue Division calls attention to the increased danger, due to this change of service, and emphasizes the necessity for a prompt study of the topographical features involved. A tentative system for streets and grades has been adopted for perhaps 25% of the total area in this borough. The triangulations to control the surveys in the various boroughs have not as yet been completed, but some results have been received from the United States Coast and Geodetic Survey giving co-ordinates of certain stations, which will be used in the location of other points.

In the Borough of Richmond 43 stations were selected for trian-

gulation points, including towers, school houses, churches, lighthouses, etc. In the Bronx 19 towers were erected, varying from 30 ft. to 84 ft. in height.

In measuring the primary traverses in Richmond Borough, it was found that excellent results were obtained, by using a 100-ft. steel tape, properly calibrated, with spring balance and thermometer, and using steel tripods to mark successive tape lengths, corrections being based on the elevations taken with a Y level. If lines when measured a second time varied more than .01 ft. + .00003 ft. × distance in feet from the original measurement, they were again remeasured.

The interior work of the surveys here as elsewhere, is filled in by the transit, plane table or other satisfactory method.

The necessity for comprehensive planning is fully recognized and careful consideration given to probable tunnels, bridges, centers of traffic, etc., and all matters which are likely to affect the future and help make a harmonious plan for the whole. The engineering and artistic possibilities involved in the suggested construction of a Boulevard on the easterly side of Richmond Borough, from Tompkinsville southerly, at an elevation of several hundred feet above the sea level, are such as can hardly be equalled for the same equal distance in this country.

The Borough of Brooklyn has had an advantage over Queens in having a more or less complete map, upon which to base the street layouts and contract work.

The opening of the Williamsburg Bridge caused a large amount of work, on the part of the Topographical Bureau, in preparing plans for the approaches thereto, as has also the proposed widening of Livingston street.

Blackwell's Island Bridge superstructure has advanced with reasonable speed, the masonry for same being practically complete and the erection of the superstructure well begun.

In The Bronx a much-needed connection from the Southern Boulevard to the Willis Avenue Bridge was completed during the year, and has proven a great convenience to the travelling public.

One Hundred and Forty-fifth Street Bridge over the Harlem River, which was delayed on account of the construction of the

Rapid Transit Tunnel, has been completed and was opened to traffic August 24th, 1905.

Work on the Two Hundred and Seventh Street Bridge approaches over the Harlem has progressed and in the near future the bridge at present located at the Ship Canal and Broadway will be transferred to this place and thus furnish one more much needed connection between Manhattan and The Bronx. A grade crossing at Fordham Heights station will be eliminated by making a crossing over the railroad tracks on the bridge approach.

The construction of the new Pelham Bridge across Eastchester Bay has been well advanced during the past year, and should be completed during the present year.

Vernon Avenue Bridge over Newtown Creek, which was one of the works inspected in 1904, has been completed and was opened October 17th, 1905, and several others are under way and in various stages of progress.

Several bridges over Gowanus Canal have been completed during 1905.

It is proposed to remove the Ninth Avenue Bridge over the Gowanus Canal and re-erect the same at Lemon Creek near Tottenville.

The changes at the Manhattan Terminal of the Brooklyn Bridge have necessitated a great amount of study and considerable expenditure of money, resulting in an alleviation of the conditions, but not in a cure for the trouble.

The proposed Hendrik Hudson Memorial Bridge, connecting Manhattan on the south with the highland of Spuyten Duyvil on the north, is one of the most notable engineering projects that have been authorized during the year 1905. The proposed plan calls for a masonry arch approach at either end and a single steel arch about 800 ft. in length spanning the waterway and the railroad tracks. The bridge as proposed is to be 80 ft. in width and about 175 ft. above the water.

Among the many other engineering accomplishments, the connecting of the rapid-transit lines under the Harlem River has made important improvements in the passenger conditions of Bronx

Borough, and the facility of reaching the down-town districts is materially increased.

Up to the present time the advantages of the Rapid Transit railroad have had a very able demonstration, and nearly 17 miles of subway are now in successful and I might almost say entirely satisfactory operation, and it is carrying nearly 1 000 000 passengers daily. The question of ventilation has been exploited by the press, and attention has been called to unpleasant conditions that have obtained to some extent, but the ability with which all problems arising during construction have been met in the past, on this work, augurs well for an adequate solution of this one in the near future.

The subway now in operation has all been constructed under the original contract let by the city in 1900. The extension of the system to Brooklyn has been continued during the year and good progress made.

Perhaps the most important feature of the rapid-transit work during the past year has been the adoption of 19 routes for future subways in Manhattan, Brooklyn, Queens and the Bronx.

The construction of these routes, as proposed, will require the building of about 165 miles of railroad, of which 80 miles will be in Manhattan Borough, 33 miles in The Bronx, and 52 miles in Brooklyn and Queens.

Preparation for these extensions involves the making of plans, which represent work amounting in the aggregate to nearly $300 000 000, all resulting from the satisfactory operation of the lines now built.

We are so much in the habit of dealing with large figures in the municipal work of this city, that we are apt to lose sight of the magnitude of the work, unless we compare it with some other work which has been well discussed, as for instance, a national undertaking like the Panama Canal.

The estimates for this work, as suggested by the former Chief Engineer, John F. Wallace, were as follows:

Cost of sea level canal.....	$230 475 725
" " 30 ft. " "	194 213 406
" " 50 ft. " "	178 013 406
" " 80 ft. " "	144 233 000

so that the spectacle confronts us of a single municipality figuring upon doing work, exceeding the estimated cost of the most expensive form suggested for the canal, by more than 30 per cent. Truly New York is a city of infinite possibilities.

Perhaps the most important progress of the year under the jurisdiction of the Department of Docks and Ferries has been putting in commission the new ferry boats between Manhattan and Richmond Boroughs, which means reduction in running time of nearly 50% and when the terminal facilities are completed, an increase in the facilities for intercourse between the two boroughs that will be of untold benefit to the residents and property owners.

The westerly portion of the Jerome Park Reservoir has been practically completed, and can be placed in regular use at any time that is desirable, and notwithstanding the many adverse criticisms upon the same it bids fair to do its work fully and as designed.

The completion of the New Croton Dam brings a sigh of relief to the city as it will furnish additional water at a period when the need of same may become serious at any time.

The letting of a contract, execution of the same, and an actual beginning of work on the Cross River Dam, furnishes to the Engineers of the city, a condition which rarely comes under their observation, viz.: the letting of an extensive contract to other than the lowest responsible bidder, upon the advice of the City's Engineers and with the approval of the Board of Estimate and Apportionment, the succeeding action of the Court in declaring the contract invalid, and all work done thereunder, illegally done and not entitled to any compensation, and the subsequent reversal of this decision and resumption of work by the original contractors.

Other sources of supply under the control of the Aqueduct Commission and the construction necessary to render the same available, for prompt use are receiving every possible attention.

The Board of Water Supply of the City of New York, was organized under Chapter 724 of the Laws of 1905, known as "Mayor McClellan's Bill." Under this law three Commissioners were appointed from names submitted (upon invitation of the Mayor) by the Chamber of Commerce, the Manufacturers' Association, and the Board of Fire Underwriters.

The Board was organized, appointed a Consulting Engineer, a Chief Engineer, and an Advisory Board of two engineers.

The Chief Engineer and one member of the Advisory Board are members of the Municipal Engineers.

The law required the Board to ascertain the available sources of water supply for the City, make necessary surveys, plans, etc., and report the same, with recommendations as to desirable action, to the Board of Estimate and Apportionment.

A thorough investigation was made of the available sources of supply, and on October 7th, 1905, the Chief Engineer advised the securing and developing of the Catskill Mountains sources as a supply for the City.

The supply obtainable from this region, if properly developed, is safely 500 000 000 gals. daily, which with the present supply from other sources will serve the City for the next 20 years.

The Board of Water Supply adopted the recommendation of the Chief Engineer and reported same to the Board of Estimate and Apportionment, by which it was approved in the latter part of October, 1905. Application was made by the city to the State Water Supply Commission, organized under Chapter 723 of the Laws of 1905, for approval of the plan, as required by the law under which the two boards were created.

A time was appointed for a hearing on November 27th, 1905, and 125 objections were filed by persons, corporations, and municipalities affected. After the final hearing the Commission has 90 days in which to approve, modify or reject the plans.

Up to the present time much work has been done by the Engineers of the Board, in the field, and a general route for the Aqueduct 86 miles in length has been determined, within small limits, and many problems in the design of the great Ashokan Reservoir have been given careful study.

If this reservoir is built with its flow line at Elevation 600, it will impound 170 thousand million gals. of water, as against 30 thousand million impounded by the New Croton Dam; the magnitude of the contemplated work can be judged by quoting from the report of the Chief Engineer of the Board, where the following figures are given.

The conduit is to be of sufficient capacity to deliver daily to the City of New York not less than 500 000 000 gallons of water. Total length of the line is 82 miles, of which 14 miles will be on the hydraulic gradient, 15 miles below the hydraulic gradient, 37 miles of cut and cover work and 16 miles of steel pipe line.

The estimated cost of constructing the Ashokan Reservoir and the Aqueduct of the capacity given, from the reservoir to Hillview Reservoir, Yonkers, including the Rye Pond Development, together with the conduit of 100 million gals. daily capacity, from Hillview Reservoir to the Boroughs of Brooklyn and Richmond, is $112 - 092 000. The foregoing insures delivery of 250 million gals. daily at Hillview Reservoir.

To furnish an additional 250 millions daily from Rondout, Schoharie and the Catskill water-sheds will cost approximately $49 765 000 additional, or a total proposed expenditure of $161 - 857 000.

This cost exceeds the estimated cost of the 80-ft. level Panama Canal by $17 624 000.

From Ashokan Reservoir to Rye and Kensico Reservoir is about 69 miles. A suitable site for a filtration plant of 500 000 000 gals. daily capacity has been found near Scarsdale, a few miles south of Kensico Reservoir.

The prompt report of the Chief Engineer was rendered possible by the previous work of the Burr-Hering-Freeman Commission and the financing of this immense project was rendered possible by the adoption of Section 10, Article VIII, Amendment to the Constitution, adopted at the last election.

"Where service rendered by public corporations is unsatisfactory, either because of its inferiority or excessive cost, it becomes the province of Government to take control of that utility for its own use."

Under the foregoing opinion, the Board of Estimate and Apportionment being satisfied of its authority to proceed in an investigation as to advisability of establishing a municipal Lighting Plant, a commission was appointed consisting of Professor Seaver, of Columbia College; Doctor Hutchinson, E. E., and N. P. Lewis, C. E., Past-President of this Society, with instructions to "report

general plans and estimate of cost for a municipal Lighting Plant, for the streets, parks and public buildings."

Four reports have been made; the first report states that a plant ample to duplicate the present public electric lighting plant in Manhattan and The Bronx would cost about $4 100 000, with substations and distributing system, using the existing ducts without cost to the City. Cost of operating the station and system is estimated at $906 000.

The second report appeared in June, after the city had purchased sites for the two main stations in Manhattan and Queens, stating that a plant to furnish all the light contemplated in the previous report and replace all other forms of illumination in streets and public buildings in Manhattan and The Bronx, would cost $7 567 000, and the fixed charges and operation were estimated at $1 269 000.

The third and fourth reports were submitted in November, 1905, and relate to the equipment for Queens and Brooklyn Boroughs. The plant is estimated to cost $6 138 000, providing for the construction of 156 miles of conduits.

The station to supply this service, and enough more current to replace all other forms of lighting in the public streets and buildings of these two boroughs, is estimated to cost about $9 485 000.

The figures given indicate that these municipal plants will furnish lighting service for public purposes in Manhattan and The Bronx, at $328 000 to $427 000, under the existing rates; while in Brooklyn and Queens it will cost from $27 000 to $68 000 more than private service, largely due to the necessity of constructing expensive conduits.

"It would appear from the reports that if there ever was an opportunity to give municipal ownership a fair trial it is in connection with the public lighting of New York City."

One of the novel productions of the year is the High Pressure water system installed at Coney Island.

The circumstances requiring the construction as planned are perhaps unlike any existing elsewhere within the city limits, and the arrangement of the system, deriving its power from gas engines, provides under normal conditions for the use of fresh water in the general distribution system, but furnished with salt water

connection for use in an emergency, taking its supply from Coney Island Creek, with an intake about 9 ft. below mean high tide. The pumps are required to attain full speed and produce the maximum pressure in one minute, and the relief valve on the discharge can be set at any pressure desired, up to 200 pounds. The hydrants are so placed that the full capacity of the system, from fourteen to eighteen 250-gal. fire streams, can be concentrated on any block in the protected district.

The completion of a number of relief sewers of large capacity in the Borough of Brooklyn as well as the extensive additions in mileage to the sewerage system of that borough, are entitled to more than passing notice, if the time at our disposal would permit.

In Bronx Borough a large relief sewer, connecting with a trunk line in Webster avenue having its outfall at the Harlem River near Highbridge, has been planned, and is at the present writing practically ready to be placed under contract. East of the Bronx River the sewerage system has been tentatively determined, and construction will, in the near future, be commenced.

The most interesting novelty in the way of highway construction to which the writer's attention has been directed, is in the extension of the Riverside Drive, where, on account of the impossibility of obtaining the required width, a cemetery being on one side and the tracks of the New York Central and Hudson River Railroad on the other, the roadway is cantilevered over the tracks and about 60 ft. above them, for a distance of several hundred feet. The estimated cost of this work is about one and one half millions of dollars.

To give an idea of the value of work authorized by the Board of Estimate and Apportionment, for the different Boroughs, during the year 1905, I quote from the report of their Chief Engineer:

Borough of Manhattan.	
57 Street Improvements	$ 646 980
30 Sewer Improvements	218 550
	$865 530
Borough of Brooklyn.	
119 Street Improvements	$1 009 700
110 Sewer Improvements	848 450
	$1 858 150

Borough of The Bronx.	
60 Street Improvements	$1 559 300
37 Sewer Improvements	537 900
	$2 097 200
Borough of Queens.	
34 Street Improvements	$566 250
28 Sewer Improvements	406 500
	$972 750
Borough of Richmond.	
24 Street Improvements	$55 700
4 Sewer Improvements	16 800
	$72 500

making a total of 483 improvements authorized, amounting to $5 866 130 or an increase over the year 1904 of $1 709 640.

When it is considered that the foregoing represents only assessable work, and does not include contracts to be done under Bond Issues, the extent of engineering activities in the city can perhaps be partially appreciated.

Before closing let me call attention to a very few of the Engineering projects under way within the City limits, distinctly under private corporations, but which require more or less supervision from various departments of the City.

Among those to which attention is directed are the following:

The Pennsylvania Station and Tunnels; New York Central and Hudson River Railroad, Track Depression and Terminal; the abolishing of grade crossings, and six-tracking of the New York, New Haven and Hartford Railroad north of the Harlem River; the Depression of the Port Morris Branch of the New York Central Railroad from the existing tracks near One Hundred and Fifty-sixth Street to the Harlem River, and the erection of an Electric Power Plant for the New York Central and Hudson River Railroad on the East River at Port Morris.

By the foregoing, I have attempted to give an outline of Engineering progress in the City of New York, under the control of same, and to some extent under inspection by the City authorities.

PRESENTATION OF MEDALS.

To JAMES COPPER BAYLES, M. E., Ph. D.
For his paper entitled: The Problem of the Maintenance of Asphalt Pavements in Manhattan (Proceedings of 1903), and

To GEORGE WILLIAM TILLSON, C. E., M. Am. Soc. C. E.
For his paper entitled: The Maintenance and Repairs of Asphalt Pavements (Proceedings of 1904),

To NELSON P. LEWIS, Past-President of the Society, and
To SAMUEL C. THOMPSON, Past-President of the Society.

SAMUEL C. THOMPSON, President of the Society.—It becomes my pleasant duty and privilege to present to the authors of the prize papers the medals which were voted to them and which, in the case of Dr. Bayles, he has probably begun to think is a myth which would not materialize. This matter should have come up, under ordinary conditions, in the September meeting, but it was delayed on account of the inability of the Committee to get a badge which they thought was suitable and satisfactory in every way.

I take great pleasure in presenting to Dr. Bayles the badge which was awarded to him, and had I the power of talking or writing, as the gentleman himself has done (you, perhaps, may have seen it in his "Lines to an Absent Wife"), I would make the presentation in more forceful and graceful language than I am able to do, but, not attempting to do that, I will simply pass the badge to Dr. Bayles who, I see, is present, hoping and trusting that it will be a constant reminder of the good will of the Society and of the appreciation of the paper which he was so kind as to bring to their attention.

DR. BAYLES.—Mr. President and Gentlemen: I am very much honored and complimented, but I think the occasion is one which calls for me to make a brief explanation. On the occasion of the paper that it was announced I was to read, a paper on the unification of laboratories of the City, with a view of ascertaining a fixed standard for chemical work, I had trouble with my eyes and could

not write. I think it was within four hours of the time when the paper was to have been read that I knocked together the paper I did read and came here with it. You could have heard my heart beating when I stepped before the audience to read it. But it sometimes happens that the things you don't put the most labor on are those which represent the most usefulness, and that seemed to be the case in this instance. I thank you very much, gentlemen.

MR. THOMPSON.—Gentlemen, when you get a good thing, or get into the habit of doing a good thing, it is very proper to keep it up, and it gives me pleasure to continue the habit and to bestow upon Mr. Tillson, for his article on "The Maintenance and Repairs of Asphalt Pavements," the second annual prize which was awarded by the Committee, and to call attention to what appears to be an asphalt combination in this Society. Dr. Bayles's paper is on the asphalt subject and Mr. Tillson's is in the same line. It would seem as if the asphalt combination predominated in the Society to some extent.

Mr. Tillson, I take great pleasure in presenting to you the medal of the Society for the paper read by you at the meeting of March 23d, 1904.

MR. TILLSON.—Mr. President and Gentlemen: I appreciate very highly the gift that you have made me this evening. I have already seen it, so that I can say that possibly it is a little large for a modest man to wear on every occasion, but I shall wear it and, I trust, with pardonable pride, on every occasion when I deem it proper. It is certainly a very beautiful thing, one that is pleasing to look upon from its very design, if nothing more, but when the owner knows what it stands for, he must feel very much more pleased and he cannot help feeling a pride in wearing it. I thank you, gentlemen.

GEORGE S. RICE, First Vice-President Elect of the Society.—Gentlemen of the Society: Inasmuch as we have passed the experimental stage in the formation of our Society, it is now befitting and most appropriate to show, in some substantial manner, to those gentlemen who have taken the helm and steadfastly piloted us successfully through every stage of our organization due appreciation; and the pleasant duty devolves upon me to present, on behalf of the Society, as a memento of our respect and

regard, a medal to each of the first two Presidents which the Society has voted to give them, by which they will be duly labeled "Past-President." Although now relegated to this distinction, I hope they will not forget that we will want their help and good counsel as much in the future as we have been fortunate to have it in the past. I present these medals to Mr. Nelson P. Lewis and Mr. Samuel C. Thompson.

MR. LEWIS.—For myself, gentlemen, I wish to heartily thank you. You may have noticed, perhaps, that I came in just in time to be decorated. This was not done intentionally. To tell the truth, for some unaccountable reason, I felt far from well this evening and had about concluded that I would be unable to get here, but I pulled myself together and resolved that I would be here if I had to come in an ambulance. I appreciate this souvenir and will cherish it always. I shall never cease to be proud of it. It was my good fortune to be the first President of the Municipal Engineers of the City of New York, and while I cannot always be as active as I was during the first two years, I shall have this jewel to remind me of very happy experiences and very loyal support from you gentlemen of the Society. I thank you very much.

MR. THOMPSON.—Gentlemen: I can, in a way, but reiterate practically what Mr. Lewis has said. This badge, which I have received from you to-night, is something which I shall prize very highly, not because of its intrinsic worth but because it will constantly remind me of the pleasant associations that I have had in this Society since its formation. I took this office at the beginning of the year with a good deal of misgiving and I haven't entirely gotten over that yet. My duties were particularly arduous, following, as they did, the first Past-President, and I have not satisfied myself that my efforts have proven entirely acceptable to the Society. I can only thank you for the loyalty that that you have shown me in my position and the attention that has been given at all times in trying to assist me in my work. I now take pleasure in introducing my successor in office, Mr. Geo. W. Tillson. Will you kindly take the gavel and assume your office?

MR. TILLSON.—Gentlemen of the Municipal Engineers of the City: It must be a pleasure to a man who is a member of any

Society to be elected its President, but when it is such a Society as this, when it stands for what this Society stands for—the advancement of the profession of civil engineering—it must be especially gratifying, and there is no need of my telling you how much I am gratified and pleased at your action here this evening.

You know, when this Society was first organized, it was discussed very much, by engineers who were eligible for membership in it and by those who were not, whether, first, such a society could be successful, and second, whether there was any demand for it.

The first question, of its success, has been clearly demonstrated. While, perhaps, there is no necessity and no time to go into an argument in favor of the demand for such a society, there are a few things that have come to my notice lately which I deem it proper to mention here this evening.

A few months ago, many of you will remember, an editorial was printed in the *Engineering Record* which spoke in very flattering terms of the work of this Society. About the same time, the Secretary received a letter from the Merchants' Association acknowledging the receipt of a copy of our *Proceedings,* which he had sent to that Association; that was an exceedingly flattering letter. It was the first time, gentlemen, that we had had an opportunity of seeing ourselves as others see us, and it certainly must have been very pleasing to all of us who saw those two articles. But a few weeks ago there was another editorial in the *Engineering Record,* an extract from which I wish to read here this evening. It was quite a long editorial, but this was the part which I thought pertinent:

"But the young engineer needs professional intercourse with his fellows to broaden his views and increase his knowledge. He wants to try his wings, and he needs the kindly, helping hands of older men, who know something about him and are interested in him, to guide him in his first efforts. One cannot learn to swim without going into the water; and so the young engineer who, for any of the reasons given above, is not able to bring himself to join one of the larger societies and take part in its proceedings, might, if dependent upon those societies alone, be compelled to get along for years without that practice in written and verbal debate which is so essential to perfecting his attainments. Just here lies the best field of usefulness of the minor engineering society."

That, it seems to me, puts the question very forcibly, but it does not seem to me that that gives the real object or the real benefits to be derived from this Society.

A week ago I was talking with the City Engineer of the City of Rochester about this Society and he spoke as if he thought it must be of great advantage to all engineers in the City. "Why," said he, "a few years ago when I came to New York for information, after I had been here two or three days I knew more about the departments of New York than the people here in New York knew themselves." "Well," said I, "you cannot say that now."

Gentlemen, if you keep still in your own office, or in your own borough working along in the same lines and in the same ruts, you will work out exactly the same result that the river works out where it flows down year after year, wearing its way through the soft rock and making a deep canyon, out of which it never can get, while, on the other hand, the river that flows down through the broad, level land widens and broadens out like the Nile and fertilizes the land wherever it goes, so you will find in a society like this an influence that will benefit not only you, but will benefit every one with whom you come in contact. I do not believe that there is any one here who has attended our meetings that has not received a benefit and a full benefit, not only considering the money that he has paid in, but a benefit socially and a benefit professionally. And I want to say further that the success of this Society depends upon its President being supported by the Board of Directors and the Board of Directors being supported by the Society. And this support has been such in the past that I have no doubt it will be as strong and as great in the future.

I wish to thank you very cordially and very earnestly and to assure you, although I hope it is not needed, that in the year to come, I will do my best to further and to increase the power and the glory and the influence of the Municipal Engineers of the City of New York.

INFORMATION.

LOCATION.—The Society Quarters are at Cambridge Court, West Forty-ninth Street, Manhattan. Telephone 3147 Bryant.

MEETINGS.—Regular meetings are held in the hall of the Chemists' Club, No. 108 West Fifty-fifth Street, Manhattan, on the fourth Wednesday of each month at 8:15 o'clock, except in June, July and August. The Annual Meeting is held on the fourth Wednesday in January.

LIBRARY.—The Society rooms and library are open every day and evening, including Sundays and holidays.

Members of the Society and all who feel an interest in the maintenance of a technical reference library, devoted more especially to the subject of municipal engineering, are asked to donate engineering books, reports, specifications, maps, plans and photographs.

PROCEEDINGS.—The Society issues one volume of Proceedings each year, usually in May. It contains all of the papers presented during the preceding year, the annual address of the President, the final reports of special committees on professional subjects, descriptions of the works visited by the Society, and the speeches delivered at the annual banquet which are of permanent value.

This volume is furnished without extra charge to members and is sold for $1.50 in cloth and $1.00 in paper. Exchanges are desired with other societies, libraries, colleges, etc.

PAPERS.—Papers and discussions on subjects of engineering interest are invited from all persons, whether members of the Society or not. They are, of course, subject to proper editorial supervision. All papers on their acceptance become the property of the Society.

BADGES.—The badge of the Society is of gold with blue enamel. It has a number only engraved upon the back and may be obtained as a pin, a watch charm, or a button. The price is $4.00. Application for it should be made to the Secretary.

REMITTANCES.—All remittances should be made payable to the order of Municipal Engineers. They should be made by check on New York or by post-office or express money order payable at New York.

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JEROME PARK RESERVOIR.

INSPECTED BY THE SOCIETY, SEPTEMBER 23D, 1905.

LOCATION.

South of Van Cortlandt Park to the Kingsbridge Road, 6 700 ft. in length, and between Sedgwick and Jerome Avenues, 2 600 ft. in width.

AREA.

Land condemned, 299 acres.

AREA.

West Basin, floor area, 91 acres.

AREA.

East Basin, floor area, 130 acres.

CONCRETE (1:2:5).

West Basin, 6 in. thick on floor; extra thickness 25 ft. adjoining the walls and slope; on slope 12 in. thick and extra thickness at upper 25-ft. zone, where it is increased from 12 in. to 30 in., the 30 in. being at top to guard against wind, frost and ice action.

Concrete required for the above being 82 000 cu. yd., equal to 625 car loads or 94 000 bbl. of Portland Cement.

ELEVATIONS.

Floor of East and West Basins above H. W., at side walls, 105; at division walls, 107. Elevation of surface of water, 131.5 or 26.5 ft., greatest depth. Top of side walls, Elevation 134. Top of embankment, Elevation 136.5. Top of division wall, North End Elevation 136.5; South End Elevation 134.0.

CAPACITY.

East Basin .....1 130 000 000 gal.
West Basin ..... 765 158 000 "

SUPPLIED.

By a branch conduit, horse-shoe shape, equal to a 14-ft. circle, leaving the New Aqueduct, where it is not under pressure, at Gate House No. 1, one mile north of the reservoir; located through Van Cortlandt Park, 50 ft. east of the Old Aqueduct. This supply can be discharged into either side of the reservoir at Gate House No. 7 or taken through the conduit built in the division wall to Gate House No. 5, the central chambers where the water can be let into either basin or sent through the 48-in. pipe lines, across the reservoirs, to either Gate Houses No. 2 and 3 on the westerly margin, or to Gate House No. 4 on the easterly margin; from these gate houses into the City mains or into the basins—the latter for better circulation in the reservoir. Then the water can be passed on from Gate House No. 5 south, through either an easterly or westerly 11-ft. circular conduit to the southerly end of the basins for a better circulation of the water. The water received through the "Old Aqueduct" can be let into either basin at Gate House No. 7, north end of reservoir, or will pass south through the division wall around Gate House No. 5, on its normal grade; or can be diverted into this gate house and into the pipe lines or the reservoir basins.

The "Old Aqueduct" can be charged with a supply from either basin at Gate House No. 5 or from the East Basin, Gate House No. 6 at south end, Kingsbridge Road. Through the system the water can have good circulation and distribution.

The reservoir was designed for a storage reservoir.

The High Service Station on Jerome Avenue, at Two Hundred and Sixth Street, can be supplied from the new reservoir or from Williamsbridge Reservoir and the "Old Aqueduct" in Van Cortlandt Park.

EARTH AND ROCK REMOVED TO DATE.

(Approx.)

	Cu. Yd.		Cu. Yd.
East Basin, Earth....	1 775 000	Rock....	960 000
West Basin, "	1 410 000	"	1 560 000
Aqueduct North, Earth	72 000	"	42 000
Totals	3 257 000		2 562 000

MASONRY OF ALL KINDS LAID TO DATE.

(Approx.)

341 000 cu. yd.

The cost of construction of the new reservoir to date is $5 450 000. The total cost when completed, including purchase of 300 acres of land, will be about $6 500 per million gallons.

POWER PLANT.—INTERBOROUGH RAPID TRANSIT COMPANY.—ELEVENTH AVENUE AND FIFTY-EIGHTH STREET, MANHATTAN.

INSPECTED BY THE SOCIETY DECEMBER 9TH, 1905.

Location and General Plan of Power House.—The building is large and fully equipped and will be capable of producing more power than any electrical plant ever built. The face of the building on Eleventh Avenue is 200 ft. wide, and the total length is 694 ft.

The structure is divided longitudinally in two main parts. Operating room section 117 ft. wide, and boiler room section 83 ft. wide, each practically symmetrical with respect to its center, separated by a partition wall. In the operating room section are located the engines and generators with galleries on each side for electrical apparatus and steam pipe equipment. In the boiler room section are located the boilers, feed pumps, condensing equipments, economizers, coal bunkers, etc.

The equipment of the structure is divided into 6 generating sections, each embracing 12 boilers, 2 engines (direct connected to), a 5 000 kilowatt alternator, 2 condensing equipments, 2 boiler feed pumps, 2 smoke-flue systems, one chimney, and detail apparatus necessary to make each generating section complete in itself. There is also an engine and turbine equipment under contract.

The boiler room section is so arranged that the boilers are all on one floor symmetrically placed on each side of a longitudinal passage, with the equipment for removing ashes in the basement beneath. The economizers with their auxiliary smoke-flue connections are placed on the floor above the boilers. The coal bunkers are constructed above the economizers. The boilers, economizers, coal bunkers, etc., are arranged symmetrically with respect to each of the 6 chimneys.

There are 7 coal bunkers, of which 5 are 77 ft. and 2 are 41 ft. in length by 60 ft. in width at the top. The combined maximum capacity is 18 000 tons. The bottom of the bunkers are at the fifth

floor, 66 ft. above the basement. They are separated from each other by the 6 chimneys spaced along the longitudinal center line of the boiler house.

Chimneys.—The complete powerhouse has 6 chimneys spaced 108 ft. apart, each having an inside diameter of 15 ft. at its top, which is 225 ft. above the grate bars. Each will serve 12 boilers included in the section of which it is the center. The chimneys are not erected through the building, but are supported upon the steel structure of the building at an elevation of 76 ft. above the basement floor. The supporting platforms in each case consist of a grillage of 20-in. I-beams filled solidly with concrete, resting on 3 single web girders 8 ft. deep, supported on 6 of the building columns. A system of bracing for both chimney platforms and coal bunkers is carried down to the foundations in traverse planes about 30 ft. apart.

Each chimney is 162 ft. in total height of brickwork above the supporting platform and weighs practically 1 200 tons.

Power House Superstructure.—The building is of steel frame work with brick walls, the latter being self supporting and independent of the steel structure; they are used as bearing walls for only a few of the beams in the first floor. There are 58 transverse and 9 longitudinal rows of main columns, the longitudinal spacing being 18 ft. and 36 ft. for different rows with special bracing in the boiler house, adapted to the arrangement of boilers. The columns are mainly of box section, made up of rolled or built-up channels and cover plates. They are supported by cast iron bases, resting on concrete foundation piers with granite cap stones.

The total weight of structural steel used in the building is about 11 000 tons.

The foundation floor of the building between the column bases is a continuous mass of concrete nowhere less than 2 ft. thick, the total amount of concrete in the foundations (including foundations for the reciprocating engines) is about 80 000 cu. yd.

The floor construction throughout the building consists of concrete reinforced with expanded metal.

The face work of the powerhouse was designed under the advice of Mr. Stanford White of McKim, Mead & White. The general character of architecture may be called French Renaissance. The

walls consist of a base course of granite up to the water table, with light colored buff pressed brick above, ornamented by terra cotta pilasters, entablatures, parts of cornice, and parapet work, etc.

Some of the loads carried by the steel structure of the boiler house per longitudinal foot of the building are as follows: Coal in bunkers about 45 tons, chimneys about 4½ tons. The suspended weight of the boilers is 96 tons each, and the weight of the boiler setting 160 tons each.

Water for Condensing Purposes.—Water for condensing purposes is drawn from and discharged into the river through two concrete tunnels. The intake conduit has an oval interior section 10 ft. by 8.5 ft. in size; the outflow tunnel has a horseshoe interior section, and is on top of the intake tunnel. These tunnels were built throughout in open trench. The river end of the excavation, almost entirely through fill and mud, was carried on by means of a coffer-dam. In this portion the tunnel sections were built on a foundation of piles driven to rock and cut off 19.5 ft. below mean high water. The tunnel sections for this portion of the work were built in a 65 ft. by 48 ft. floating caisson, 24 ft. deep, and sunk by water ballast to a bearing of the foundation piles.

Adjacent to the above-mentioned tunnels is a third concrete tunnel of rectangular interior section 10 ft. high by 15 ft. wide, extending from the piers to the power house, in which the underground coal conveyor is installed.

Coal and Ash Handling Equipment.—The pier at the foot of West Fifty-eighth Street was especially constructed by the Department of Docks and Ferries to provide exceptional facilities for unloading coal as well as disposing of ashes.

The coal handling equipment consists of a movable electric hoisting tower with crushing and weighing apparatus, a system of horizontal belt conveyors, with 30-in. belts to carry the crushed and weighed coal along the dock and thence by tunnel to the south-west corner of the power house, where a system of 30-in. belt conveyors elevates it to the top of the boiler house (110 ft.) at the rate of 250 tons per hour. The coal is then distributed to the bunkers by 20-in. belt conveyors.

The equipment for the removal of ashes from the boiler room basement consists of a system of tracks (24-in. gauge) running

under the ash hoppers and extending to an elevated storage bunker of 1 000 tons capacity at the water front. The ashes are received from the hoppers in steel cars of 2 tons capacity (24 in number) and delivered to an elevating belt conveyor which raises the ashes to the storage bunker. The ashes are delivered to the barges through a collecting and a loading belt.

RAPID TRANSIT SUBWAY.—FORT WASHINGTON TUNNEL.

INSPECTED BY THE SOCIETY DECEMBER 30TH, 1905.

General Description.—The portion of the contract Sections 13 and 14 (One Hundred and Thirty-third Street to Dyckman Street) which extends north to One Hundred and Fifty-seventh Street Station, has been operated since the autumn of 1904. The portion north of One Hundred and Fifty-seventh Street Station is not at present operated, except the part between One Hundred and Fifty-seventh Street Station and One Hundred Sixty-fifth Street, which is used for storing and switching purposes.

Beginning at the north end of One Hundred and Fifty-seventh Street Station, the subway is open cut arch construction for a distance of 134 ft. (9.5 ft. north of the north side of One Hundred and Fifty-eighth Street), and from that point to Fort George (about Two Hundredth Street), a distance of 10 369.5 ft. (practically 2 miles) it is tunnel arch construction; from this point to the present portal, 45 ft., open cut arch construction was used; from the portal north for a distance of 210 ft. the construction is in open cut with concrete retaining walls; from this point to the steel viaduct, a distance of 282 ft., the work is embankment with concrete retaining walls, which also serve as the supporting walls for the platforms of Dyckman Street Station. There are two shafts in the tunnel, one at One Hundred and Sixty-eighth Street and one at One Hundred and Eighty-first Street Station, 3 536.7 ft. apart.

Tunnel Arch Construction.—The masonry lining of the entire deep tunnel sections, which is of concrete throughout, consists of a floor 4 in. thick; vertical side-walls 25 ft. apart carrying a semi-circular arch 18 in. thick, except in the timbered portions, treated later, where the thickness of the arch was increased to 21 in., and in some cases to 24 and 27 in. The thickness of the floor was increased if the rock was blasted out below the proper excavation line, so that back-filling was necessary. The side-walls as well as the toe-walls (extending 2 ft. in front of the side-walls), were carried down

to rock in all cases. The arch is full centered, with a span of 25 ft.; the springing line is 6 ft. 2 in. above the concrete floor (5 ft. 6 in. above the base of rail), hence the maximum clearance above the base of rail is 18 ft. The side-walls and arch were built solid to rock to a height of 8 ft. above the springing line no matter how much beyond the theoretical excavation line the rock happened to be blasted out. Above that point the space beyond the theoretical excavation line was dry packed with small stone placed by hand.

The concrete consists of Giant Portland cement, Cow Bay sand and broken stone, mixed in proportion of 1 : 2½ : 5.

Tunnel Excavation.—The method of excavation was substantially the single top heading and bench method commonly employed in the United States in rock tunnel work, the heading being taken out first about 16 ft. wide and 8.5 ft. deep and then trimmed out to about full width, and the bench taken out. The face of the bench and the trimming was constantly kept about 15 ft. back of the face of the heading.

The entire tunnel excavation on Sections 13 and 14 was carried on by driving headings from each of the four portals (including also One Hundred and Fifty-first to One Hundred and Fifty-fifth Street tunnel), and north and south headings from each of the shafts, making in all 8 working points.

The removal of spoil was accomplished by means of dump cars running on 36-in. gauge service tracks in the tunnel. At One Hundred and Fifty-seventh Street an incline was used branching north and south into One Hundred and Fifty-fifth and One Hundred and Fifty-eighth Street portals respectively. The cars were hauled to the portals by mules and then taken up the inclines to the dump at One Hundred and Sixty-second Street and Lafayette Boulevard by locomotives. At One Hundred and Fifty-first Street portal the material was hoisted out and taken to the One Hundred and Sixty-second Street dump by teams. At One Hundred and Sixty-eighth Street shaft the material was taken to the One Hundred and Sixty-second Street dump in cars hauled by mules. At One Hundred and Eighty-first Street shaft teams were used to deliver the spoil to various dumps, which were generally nearby. At Fort George the material was hauled by mules direct to the dump near the portal.

On Sections 13 and 14 there is 2 275 ft. of "heavy" ground re-

quiring permanent timbering, which included approximately 500 ft. of soft ground tunneling. The permanent timbering through the sections of "heavy" ground consisted of segmental arches, spaced from 3 ft. to 5 ft. apart, each made up of 7 timbers 10 in. by 10 in. or 12 in. by 12 in., 5 ft. 2 in. long on the intrados and 5 ft. 6 in. on the extrados. These segmental arches are erected on wall plates about 16 ft. long by 14 in. by 14 in. or 12 in. by 12 in. cut skew back. The "wall plates" are supported by 10 in. by 10 in. or 12 in. by 12 in. plumb posts reaching below subgrade and placed in the same vertical planes as the segmental arches. Where there was soft ground the crown bar and poling board method of excavation was used, the final support for the crown bars being the segmental arches mentioned above.

One Hundred and Sixty-eighth Street and One Hundred and Eighty-first Street Shafts and Stations.—The shafts at One Hundred and Sixty-eighth and One Hundred and Eighty-first Streets were designed to be permanent and to furnish entrances to the underground stations located at these points.

One Hundred and Sixty-eighth Street shaft is 103 ft. deep by 15 ft. by 32 ft. The center line of the shaft is located 61.8 ft. east of the center line of the tunnel. This shaft was begun July 2nd, 1900, and completed to sub-grade November 7th, 1900, or in 101 working days.

One Hundred and Eighty-first Street shaft is 126 ft. deep by 15 ft. by 32 ft. The center line of the shaft is located 60.9 ft. east of the center line of the tunnel. This shaft was began July 24th, 1900, and completed to sub-grade December 15th, 1900, or in 131 working days.

Both shafts are connected with the main tunnel by cross drifts at right angles to the center line of the tunnel.

The main station arches at both One Hundred and Sixty-eighth and One Hundred and Eighty-first Street stations are 300 ft. long with a 48-ft. clear span and a maximum height above the base of rail of 26 ft. The masonry lining consists of a concrete floor, as in the regular tunnel before mentioned, concrete platforms and supporting walls, concrete side-walls 2 ft. 6 in. thick, carrying a brick arch 2 ft. 6 inches thick, consisting of 6 rings of common brick and a face course of hard cream building brick. The main station

arches are 3 centered, of 32 ft. and 13.94 ft. radii. The cross drift masonry consists of a concrete platform leading to the shafts, concrete side-walls (18 in. thick) carrying a brick arch consisting of hard cream brick 18 in. thick. The drift arches are 3 centered, of 19-ft. and 5.92-ft. radii, with a clear span of 26 ft. The maximum height is the same as the main station arch, 26 ft. above base of rail. In each case the side-walls are carried solid to rock and brick arch backed solid to rock with concrete to a height of 12 ft. above springing line and dry packed above that point.

The shafts are designed for 2 elevators and one stairway each. They will be lined with concrete and steel. The ticket offices, toilet rooms, etc., are to be located just below the surface of the street, and of course connecting with the shafts.

It is worthy of note that on March 29th, 1905, a burning train caused great damage to the brick work at One Hundred and Sixty-eighth Street Station (burning 2 sets of centers in place under the brick arches). This necessitated taking out and replacing a large part of the face course of brick then in place. This repair work is very slow and expensive.

The finish work at One Hundred and Sixty-eighth Street Station will be a base course of 4 rows of red brick with tile wainscoting surmounted by a 6-in. marble cap course, and between the marble and the cream brick before mentioned, there will be a 15-in. ceramic band, which also extends along the groin at the junction of the main and cross drift arches.

At One Hundred and Eighty-first Street Station the finish will be the same, except that a red brick wainscoting (partly in place) will be used instead of the tile. The light centers in the roof are ornamental terra cotta.

Fort George Portal and Cut.—The portal masonry consists of a granite arched ring surmounted by an ornamental concrete parapet. Joining the stone work on the west is a concrete retaining wall in the same plane as the face of the portal. Along the east side is a concrete retaining wall sloping down with the hill toward the north. The greatest height of this wall (at portal) is 32 ft. above base of rail and the greatest thickness at the base it 15 ft.

Dyckman Street Station.—This station is located at the junction of Hillside and Eleventh (St. Nicholas) Avenues, just south of

Dyckman Street. The platforms are located partly on embankment and partly on the steel viaduct which begins here and runs north to Kingsbridge. The ticket office, waiting-room, toilets, etc., are located under the steel on the level of Eleventh Avenue. The platforms are supported for the greater part of their length on concrete walls, but at the north end they are supported on steel girders.

The ticket office is built entirely of concrete of ornamental design with large window arches on the west or Hillside Avenue side. Extending along Hillside Avenue, a series of booths of the same general design as the ticket office have been constructed in the space between the retaining wall and the building line. This series of concrete piers and arches which form the Hillside Avenue face is 1 ft. thick. The openings are to be filled with wood paneling and plate glass, with doors for entrance and exit. South of the booths along Hillside Avenue the concrete work consists of a concrete retaining wall with pilasters 3 ft. 6 in. wide, standing out 4 in. from the wall. The panels between the pilasters are to be "bush" hammered. The ornamental concrete work at this station is to be smoothed down and finished as soon as it can be done without danger of freezing.

Data.—The total length of the actual deep tunnel is 11 480.5 ft. (2.19 miles), the longest double-track tunnel in America.

Total tunnel excavation is about 211 750 cu. yd., including only the excavation inside the theoretical line.

Tunnel excavation per linear ft.,	18-in.	ring,	is	18.14	cu. yd.
Concrete tunnel lining per linear ft.,	"	"	"	3.47	" "
	21-in.	"	"	4.00	" "
	24-in.	"	"	4.5	" "
	27-in.	"	"	5.08	" "

The grade through the entire tunnel north of One Hundred and Fifty-seventh Street Station is —.36%, except at One Hundred and Sixty-eighth Street and One Hundred and Eighty-first Street Stations, where for about 450 ft. south of the stations there is a grade of +1%, and for a distance of about 500 ft. north of the station the grade is —1.5 per cent.

The tunnel is drained by a system of 3-in. tile drains running from the haunch line of the arch back of the concrete side-walls and

under the floor, connecting with a main center drain (tile) under the floor, which varies in diameter from 6 in. to 15 in. The 3-in. drains are spaced according to the requirements of the situation, but never more than 20 ft. apart on each side.

All concrete was machine mixed, and nearly all the stone was crushed on the work.

ANNUAL DINNER.

The Third Annual Dinner of the Society was held at the St. Denis Hotel, January 10, 1906. There were one hundred and seventy-four members and guests present. No formal speeches were announced, but several responses were made to the invitation of the toastmaster, Mr. Samuel C. Thompson, President of the Society.

CHARLES WHITING BAKER, ESQ., Editor of *Engineering News*, spoke as follows:

I have been thinking, as I watch the remarkable growth of your Society, that after all its growth is only beginning. It will grow in future with the extension of the City's activities, and that leads me to the thought of what these extensions are to be.

No one who looks without prejudice at the progress of the past fifteen or ten or five years can fail to be impressed with the steady trend toward municipal ownership. That means that your Society of the future as it meets here, years hence, will not only include the engineers of the Water Department, of the Street Department, of the Sewer Department, of the Topographical Department, but it will include, if I mistake not, the engineers in charge of the gas lighting of this City, of the electric lighting of the City, and when I say lighting, I mean not only lighting the streets and the public buildings, but furnishing the entire supply of light for the city's inhabitants. It will include, probably, also the engineers in charge of the transportation facilities of the City, the street railways.

Now, this may seem like a long step in advance but it is a step that appears to be sure to come. We may not like it; we may think it is a mistake; or, on the other hand, we may be greatly in favor of it; but looking at it with an unprejudiced eye, we must see that the tendency is all in that direction.

Just a few instances may show the change in public opinion. It is only a few years ago that people were obtaining franchises to construct bridges across the East River, and across the North River, as a private enterprise. We do not hear of that any more. If a bridge is to be built, the City builds it and owns it; it is as

much a part of the City as are the City's streets. A few years ago, too, we heard very little talk about any interference with such functions of municipal supply as the gas or the electric light, or the street railway; but now the City is stepping in to try to control these municipal activities. And it is going farther than that: within this very year that has just closed, your Past-President and others who are here to-night have prepared detail plans for the building of a municipal electric lighting plant, and that is the entering wedge, in all probability, toward much larger municipal activity in that direction.

Now we may oppose this movement, or we may favor it, but no one who looks carefully at the political signs of the times can fail to see that the voters have made up their minds that municipal ownership is the policy to pursue in the future and that, whenever the issue is squarely and fairly presented to them, a large majority is found in its favor.

I am not going to detain you with any long argument in favor of municipal ownership or against it, but perhaps I can say one or two things that may be worth your while, if you wish, as every engineer must, to form a sound opinion on this important public question.

Be very careful when you read the publications that appear in the daily newspapers and elsewhere arguing pro and con on this subject and particularly the arguments against municipal ownership, that the argument is made in good faith. We have here a peculiar condition. On the side that opposes municipal ownership there are very heavy interests. There are millions already at stake and uncounted millions more which the exploiters of franchises seek to grasp. It would be only human nature that the people who have such great interests should leave no stone unturned to make things go their way. Where they can influence public opinion toward their side of the case, they will put forth every effort to that end.

One notable instance that may illustrate the methods by which corporate interests work to defeat municipal ownership was the transfer of the Philadelphia municipal gas works a few years ago to a private corporation. The real underlying motive of that transfer, there can be little doubt, was the fact that the private owners

of gas companies did not want to have that example of municipal ownership staring them in the face. The time was coming when the people of other cities would say: "If Philadelphia can furnish its inhabitants gas from municipal works at a low rate, we can do the same;" and for that reason a bargain was made by which the works were turned over to a private company, notwithstanding the fight made by many patriotic Philadelphians.

However, in spite of all the efforts of these powerful interests an irresistible tide is setting toward municipal ownership. Hardly a week passes but we find some private water company being turned over to city ownership and control. In Great Britain, in Germany, in France, they have gone much farther than we have in this country. It is true the results obtained are in controversy, but I again suggest to you that in forming an opinion on these things you be very sure that the facts on which you base your opinions are stated without prejudice and so stated that you can be sure they are true.

There is one argument brought against municipal ownership of which I think this gathering before me is sufficient contradiction. That is the claim that the City cannot be trusted to manage its own affairs because it cannot obtain, to do its work, efficient men. Let us remember, in considering this question, that the work of electric lighting, the work of the street railways, the work of water supply, must be done by engineers any way; whether a private corporation does it, or whether a municipal corporation does it, the real work must be done by engineers. It is merely a question, then, whether the engineers shall be employed by the City directly or by a private company.

Now, a great deal is said by those who argue against municipal ownership, about the misfortune of the engineers in public employ. It is said that they are subject to all sorts of political vicissitudes; that they are never sure of their tenure of office; that they are poorly paid; that they are overworked, and so on. But, on the other hand, the fact is, that there is not always a bed of roses for the engineer in the employ of a private company. So far as I have noticed, private corporations, when they employ engineers, are very apt to pay the market rate of wages. In other words, they get the engineer for as little money as they can and they do not pay any more. From a large observation of engineers in both public

and private employ, I am inclined to believe that the average engineer in public employ is, as a rule, quite as well off as the engineer working for a private corporation.

In regard to the argument that cities cannot obtain competent men to conduct municipal works, I have a pretty large acquaintance among engineers and some of the best engineers I know are in the employ of cities and states. I think I know quite as many engineers of high standing that are working for the public in that way as I do engineers in the employ of private companies.

Now, gentlemen, I leave these thoughts with you, and in closing I want to suggest to you the really strong argument in favor of municipal ownership, as it was presented at the recent meeting at Baltimore of the American Economic Association. The speaker there, in summing up the situation, said that it was not a question whether a city could furnish water more cheaply than a private company, or furnish cheaper gas or electric light, or lower street railway fares. It is not even a question whether the city will give better service than the private company. Of course, we must recognize that there are going to be imperfections in the city service just as there are, we regret to say, in the service furnished by private companies. There are going to be kickers any way and often they have reasons for kicking. The great, all-important reason why we must have municipal ownership, said the speaker, is for the sake of our municipal governments. It has come to be a question whether the city shall govern itself or whether it shall be governed by municipal franchise corporations. The city is the hope of democracy; but, for the realization of that hope, democracy must own and control all the essentials to the city's welfare.

Capt. David L. Hough, President of the United Engineering and Contracting Company, spoke of some points in connection with his work on the Pennsylvania tunnel. He said in part:

I may say that the conditions are somewhat unusual. We are driving a tunnel 85 feet below the surface on an average; that is, the tread of the rail is 85 feet below the curb line right through the center of the best residential district in town.

The Lighting Company furnish the current to drive our motors that, in turn, drive our compressors on a steam basis. Then they furnish the current which lifts the material out of the shaft by the

kilowatt hour. That is done by telfers furnished by the Dodge Coal Storage Company. We load the material excavated into skips with the steam shovel in the tunnel. They are run on cars to the shaft and there they are lifted out by an electric hoist, which, in itself, is an auto-propeller—I am afraid to say automobile; this drops the skip on to a wagon, to a platform truck. At the dock there is an automatic dump arrangement by which it is loaded on the scows. That is the way we get rid of our material. We won't have a pound of steam on the job. It will be unique in that respect, and, I think, to a certain extent, up to date; but we still have to find out what the municipal corporation, in the form of the electric light people, are going to do to us after we get done.

I would like to write you a book of conduct and tell you sometimes to be a little mellow to the poor, hard-working contractor, because he is human. He is human, gentlemen. I do not like to preach, but I just want to get this word in. If you stop to think of the men as municipal engineers who have gone to the head of your profession, who hold the highest stations, you will find that they are all men who have treated the contractor fairly, and I want you all to think about that.

Mr. George S. Rice, Chief Engineer of the Board of Rapid Transit Railroad Commissioners, spoke in part as follows:

In the routes laid out by the Rapid Transit Board a plan is considered by which every borough of Greater New York will be connected with the Borough of Manhattan. You will find in the routes laid out last May a line connecting the present rapid transit subway in the Borough of Brooklyn, from Atlantic to Flatbush Avenues, down Fourth Avenue, to Fort Hamilton. From this it may ultimately be expected that a connection with Richmond, underneath The Narrows, will be effected. So far, the Rapid Transit Board has not laid out a route, because that borough has not asked for it. I will say that practically every request made upon the Board has been acceded to where asked for and considered feasible.

The problem of connecting with Richmond is a very serious one. A channel has to be crossed with a width of 7 300 feet, and, unfortunately, with a depth of water nearly 100 ft. That means construction by a tunnel as, of course, a bridge is out of the question. Under the present method of construction, demonstrated by

Captain Hough as a contractor, under the East River, a tunnel built under these conditions means a very heavy air pressure.

About a year and a half ago it was felt by the engineers of the Rapid Transit Board that the development of the whole city would be only a matter of a few years. To-day the Rapid Transit Board is considering an expenditure—the money for which I expect will not be supplied by the City—of $300 000 000. There are nineteen routes which have been laid out, and inside of three or four months three of these routes will probably be advertised for competitive bids.

As you gentlemen know, there has lately been a merger of the interests of the subway, elevated and surface lines. I do not think that the merger will make much difference with respect to the bids for rapid transit railways of the immediate future. I am optimistic enough to believe that there will be some wholesome competitive bidding, as some people who have been in consultation with me have intimated that they are willing to bid for routes in the different boroughs, involving a large expenditure of money.

I think Captain Hough's statement with reference to the treatment of contractors by the engineers is apropos. Engineers sometimes, I fear, are a little arbitrary in their treatment of a contractor. Wherever possible, we should meet them half way and not expect them to do more than is consistent with their contracts. The contractors on the rapid transit work, I know, we have treated properly, considering them as members of our own family. I think they will all concede that in our treatment of them we have tried to look after their interests, and I hope that in contracts for future railways this cordial relation between engineer and contractor will continue.

I want to say one thing more in connection with the engineers of the City of New York and their pay: when work was organized under the Rapid Transit Board, the intention was to give good salaries, and demand, in return, good work from the engineers. That the engineers have been well paid I am sure will not be disputed, and their interests not overlooked. The Rapid Transit Board holds the engineers responsible for the work and the result is that the work has been well looked after, as I think you gentlemen will agree.

MR. GEORGE W. TILLSON, Chief Engineer of Highways for the Borough of Brooklyn, was introduced as the President-Elect of the Society for the ensuing year. He said in part:

I trust Mr. Hough will excuse me if I elaborate a little on his statement to the effect that the successful engineer has always been an engineer who has treated the contractor squarely, and to say to him that the successful contractor has been almost invariably the one who has treated the city fairly and the corporations fairly for whom he has been working. I want to say also that my experience with contractors, which has now been of some twenty-three or twenty-four years' duration, has been that I have found that in the majority of cases, if you treat the contractor right, he will treat you right. The contractors are men and made up of the ordinary mixture of human nature that other men are and that engineers are, but occasionally you will find mean contractors as well as mean engineers. I have one in mind with whom I have had considerable to do, and I have often said to him, in looking over the work for final acceptance: "If you see something in your work that would cost you $1.00 to repair at the time you see it and $5.00 if you come back to do it, you will take the chance of my not noticing it and let the $1.00 repair go upon the chance of not having to make the $5.00 repair," and that is an actual fact. That man has been in business a long while, ever since I have been there, and is doing business to-day, and he has always been that kind of a man. Now, you have to treat that man in an altogether different way from what you do a contractor who is square and honest. If you are going to drive a pile in hard pan, you don't use the same kind of force that you do if you are going to drive it in sand, and the success of the engineer in dealing with contractors is dependent upon how he can recognize the difference in contractors just the same as he can recognize the difference in soil into which he must drive his pile, and I think that is necessary in municipal engineering more than in any other one branch. The municipal engineer is a sort of buffer. He stands between the contractor and the public, and he must not only have a good knowledge of engineering and know what is the proper thing to do, but he must be so constituted that he can handle the contractor on one side and the public on the other in such a way as to get good work. In order to get good work he must have the respect

of the contractor and he must have the respect of the public, so that the public will feel that he is trying to get good work, and the contractor will understand that he is not asking of him any more than he thinks is necessary, but he must get good work, no matter what is done. The success of the municipal engineer will depend as much upon his ability to treat the contractor right and to get good work, as upon his abstract or concrete knowledge of engineering itself.

Messrs. John J. McLaughlin, Consulting Engineer for the Borough President of Queens; Rufus C. Hunt, Manager for John B. McDonald, Contractor; Louis L. Tribus, Commissioner of Public Works of Richmond, and Nelson P. Lewis, Past President of the Society and Chief Engineer to the Board of Estimate and Apportionment also accepted the opportunity to make a few remarks which added to the interest of the occasion.

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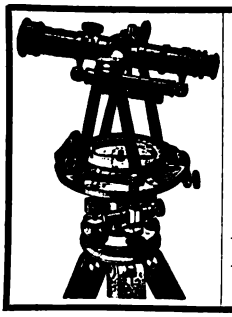

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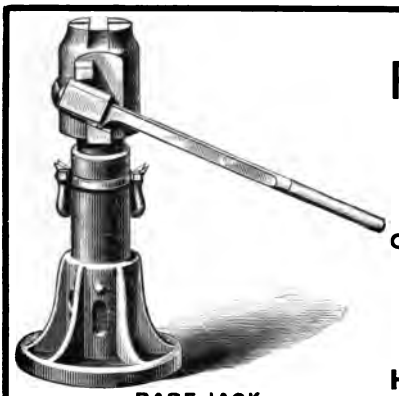

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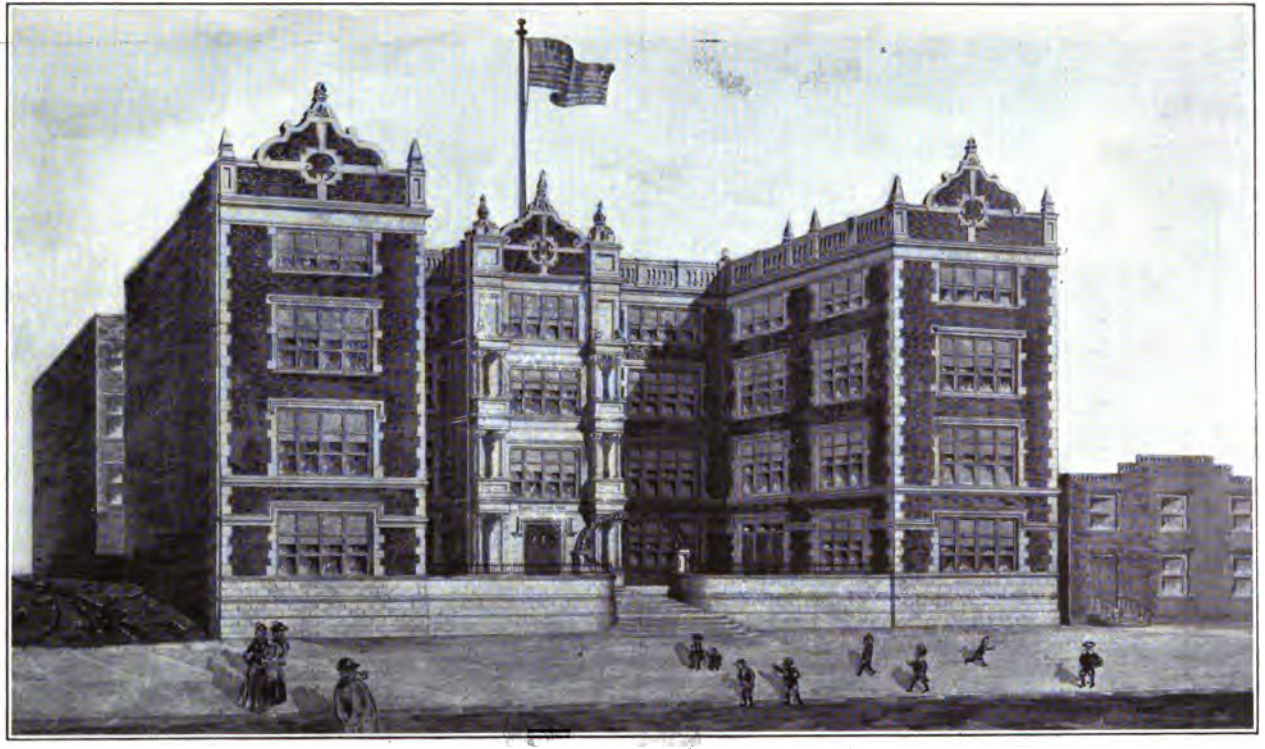

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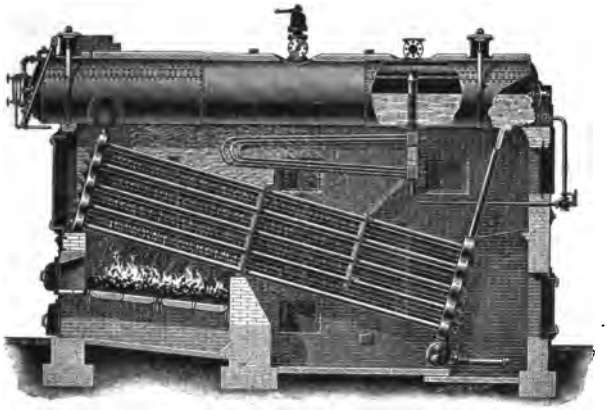

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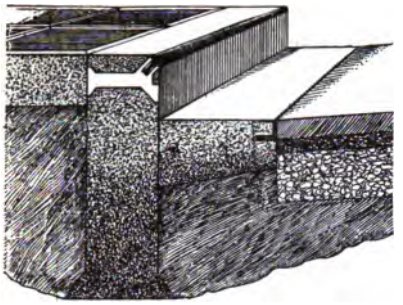

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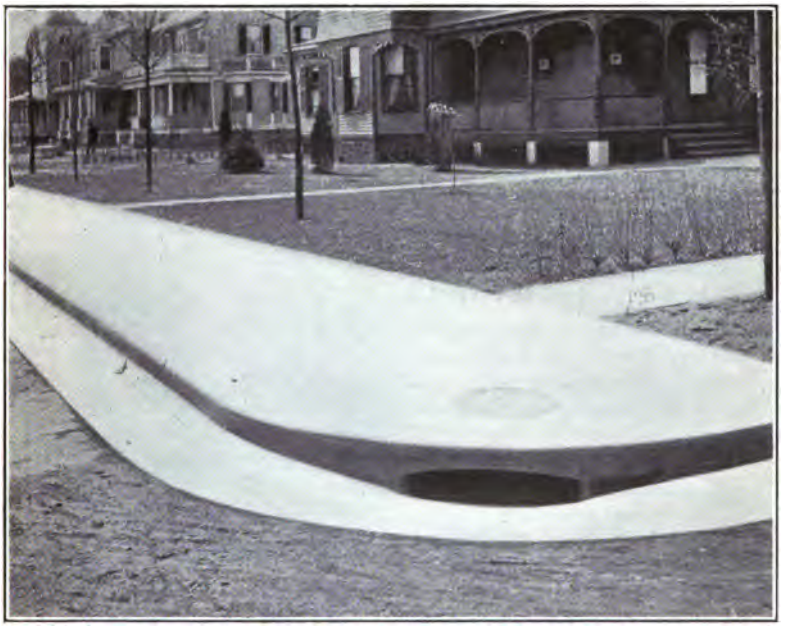

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